GECKODRIVE
MOTOR CONTROLS

GM215 User Manual

Geckodrive, Inc. - 14662 Franklin Ave - Suite E - Tustin, CA - 92780
Phone: 714.832.8874 - Fax: 714.832.8082 - www.geckodrive.com

The GM215 is a 7A, 80VDC step motor drive with an integrated motion controller. It can be used as a step and direction input motor drive or as motion control enabled drive. The operating mode and mode related functions are set via the 10-position slide switch on side of the drive. The GM215 has 3 opto-isolated inputs and 3 opto-isolated outputs. The function of the input/outputs is also determined by the selected operating mode. The features of these operating modes are described below.

STEP MOTOR DRIVE FEATURES

The GM215 can operate as a conventional STEP and DIRECTION input step motor drive.

MICROSTEPPING: The GM215 has a 10 microstep native resolution; each full step angle of the motor is divided into 10 equally spaced microsteps so a 200 step per revolution motor has 2000 stopping locations per revolution.

STEP PULSE MULTIPLIER: The GM215 synthesizes 10 microstep pulses for every full-step pulse and 5 microstep pulses for half-step pulse. The GM215 acts like a full or half-step drive but motor has the smoothness of a 10-microstep drive.

SUB-MICROSTEPPING: For the 10 microstep resolution, each input step pulse is divided into 32 sub-microsteps resulting in a motor smoothness equal to a 320 microstep drive.

MORPHING: The GM215 morphs from sine-cosine motor currents at low speeds to square-wave currents at high speeds. This technique extracts the maximum possible power from the motor at higher speeds. Morphing begins at 240RPM and ends at 360RPM.

MID-BAND RESONANCE COMPENSATION: The GM215 uses active second-order damping to completely suppress a step motor's tendency to resonate and stall at medium speeds (300RPM – 900RPM). This results in stable motor operation in this region.

LOW SPEED RESONANCE COMPENSATION: Low speed resonances are motor vibrations at speeds below 120 RPM caused by motor non-linearity. The PROFILE and ADJUST trimpots settings nulls these vibrations.

PROTECTION: The GM215 is protected against motor to ground and motor to motor output short-circuits. It is also protected against reversed power supply polarity and power supply over-voltage. The internal fuse blows on polarity reversal and over-voltage.

AUTOMATIC STANDBY CURRENT: If enabled, the motor phase current is reduced to 70% of the set value and the GM215 motor switching topology is changed to a low heating recirculating mode. This happens 1 second after the last step pulse is received.

MOTION CONTROLLER FEATURES

The GM215 motion controller core is a 16-bit MCU, FPGA, Flash ROM and an RS485 interface transceiver. The motion controller executes ASCII format commands sent from an external PC or from its own non-volatile memory.

'ON THE FLY' MOTION CONTROL: Acceleration, velocity and destination can be changed even while the motor is in motion. The new values apply immediately.

MULTIPLE AXIS MOTION: Up to 4 GM215 drives can communicate with each other to execute coordinated multi-axis motion.

RUN FROM STORED PROGRAM: The GM215 can run stored motion programs from its non-volatile Flash memory without a computer connected to it. The memory can store over 65,000 coordinates or program lines.

POWERFUL COMMAND-SET: The command-set includes 'if-then-else' conditional branching, looping and macros (subroutines). It also includes canned high-speed HOME routines, JOG routines, SPEED control routines and more.

ANALOG INPUTS: The GM215 has on-board 3 trimpots to allow setting acceleration, velocity and destination instead of using digital settings. Also the analog inputs can be summed to the digital value settings to give Vernier control over them.

GENERAL PURPOSE I/O: The GM215 has three opto-isolated user defined inputs and three opto-isolated user defined outputs.

RS-485 INTERFACE: The GM215 has both interfaces available. The default baud rate is 115,200.

BOOT-LOADER: The user can update the GM215 firmware using the built in boot-loader function.

CN1 CONNECTOR ASSIGNMENTS

Terminal	Name	Function
1	GND	DC Power supply (-)
2	VDC+	DC Power supply (+)
3	A	Motor winding A
4	/A	Motor winding A
5	B	Motor winding B
6	/B	Motor winding B

GND (TERMINAL 1)
Connect the power supply '-' to this terminal. This connection must be hard-wired to the power supply.

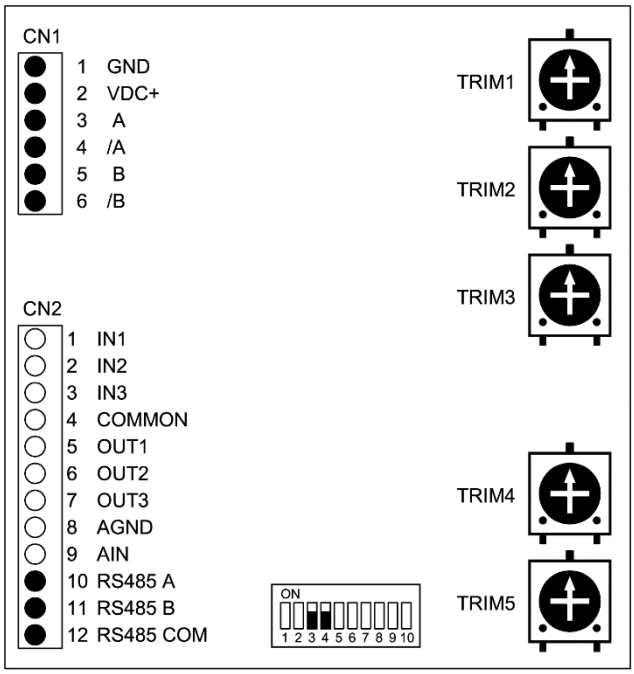
VDC+ (TERMINAL 2)
Connect the power supply '+' to this terminal. The power supply voltage must be between 18 VDC and 80 VDC and this connection must be hard-wired to the power supply. Do not use a switch, relay contact or any other device in series with this wired connection.

A (TERMINAL 3)
/A (TERMINAL 4)
Connect one motor phase winding to these terminals.

B (TERMINAL 5)
/B (TERMINAL 6)
Connect the other motor phase winding to these terminals.

TRIMPOT ADJUSTMENTS
TRIM1 and TRIM2 are used to maximize motor smoothness at speeds below 50 RPM. The Digital Self-Test feature can useful in making these adjustments. While the motor is turning, adjust TRIM1 for minimum motor vibration.

The rest of this user's manual is divided into two sections. Use the **GM215 STEP MOTOR DRIVE MANUAL** if the GM215 is used as a conventional step motor drive. Use the **GM215 MOTION CONTROLLER MANUAL** if the GM215 motion controller is used.



GM215 STEP MOTOR DRIVE MANUAL

This manual covers the GM215 when it's used as a conventional STP/DIR input step motor drive. Go to the **GM215 MOTION CONTROLLER MANUAL** if the GM215 is used as a motion controller and motor drive.

SWITCH SETTINGS AND CONNECTOR WIRING

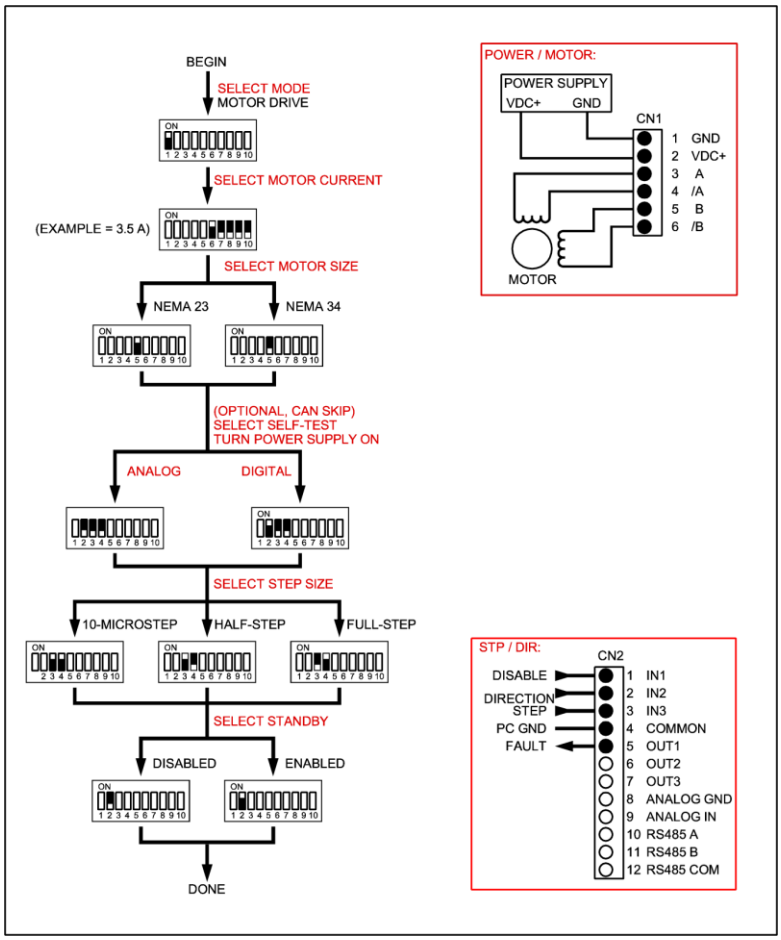


Figure 1.

GM215 SETUP FOR MOTOR DRIVE MODE

CAUTION:
Perform the following steps with the power supply turned 'OFF' until a step says it is OK to turn the power supply 'ON'. Do not change the current set switches after setup while the motor is powered.

The following switch settings and their function only applies to the Motor Drive Mode. The same switches have completely different functions in the Motion Controller Mode.

STEP 1: SELECT MOTOR DRIVE MODE
SW1 'ON' Select step motor drive mode operation. In this mode the GM215 acts like a STEP / DIRECTION motor drive and the internal motion controller isn't used.

STEP 2: SELECT MOTOR CURRENT
Use the following chart to set the GM215 to the motor's phase current rating. If a motor has a rated current that isn't listed in the table below, set the current to the first setting that is greater than the motor's rated current.

= SW is 'ON'

= SW is 'OFF'

= SW is not used to set current

WARNING! THESE SWITCHES MUST BE SET CORRECTLY BEFORE RUNNING THE GM215 WITH A MOTOR WHEN IN MOTOR DRIVE MODE OR SELF-TEST MODE
SET CURRENT BEFORE TURNING POWER ON

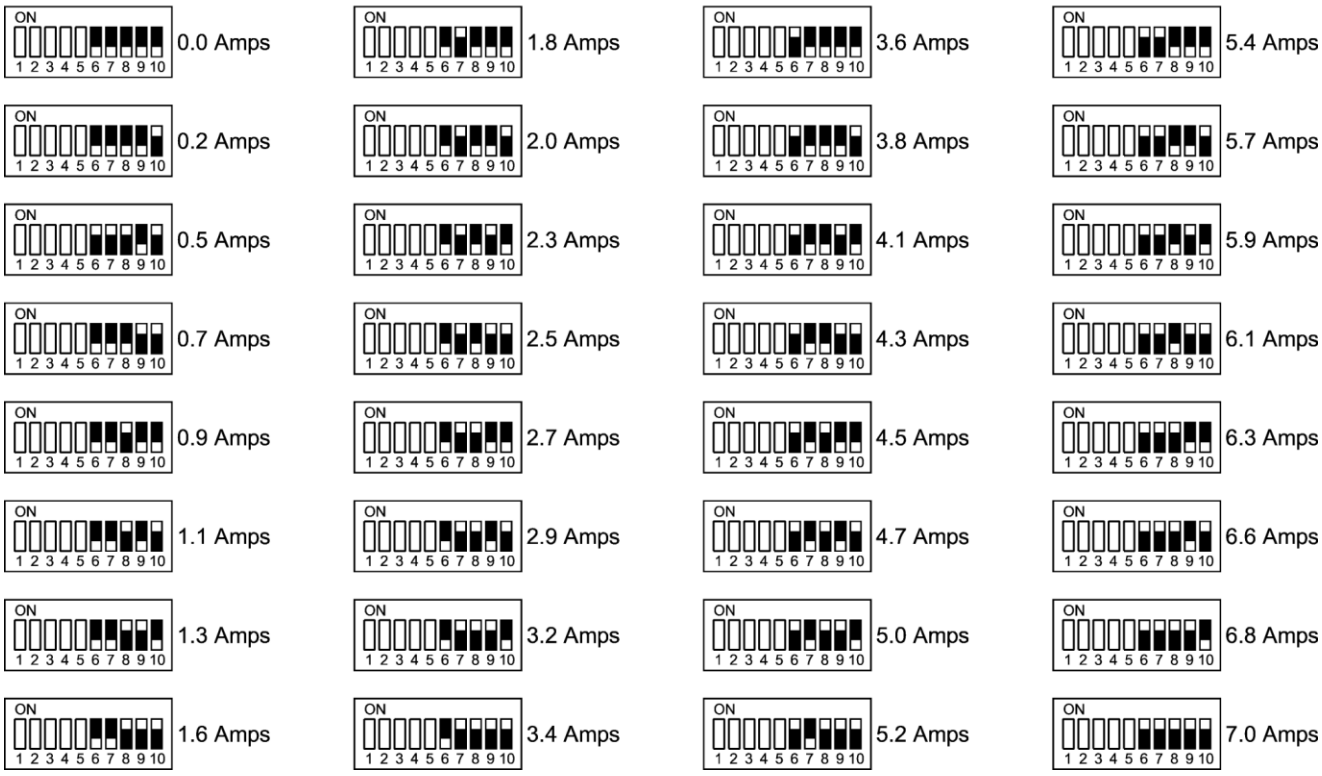


Figure 2.

STEP 3: SELECT MOTOR SIZE
Switch 5 must be set to the motor frame size.
SW5 'ON' The motor is a NEMA-23 size or smaller.
SW5 'OFF' The motor is a NEMA-34 size or larger.

STEP 4: SELECT SELF-TEST

This step is optional and it can be skipped. Self-Test can also be used after setup is completed or at any other time when it is necessary to verify the GM215 is working correctly. It can be useful when debugging a controller to GM215 interface. When finished with Self-Test, restore switches SW2, SW3, and SW4 to their previous settings to exit the Self-Test routine.

Two Self-Test routines available, Digital and Analog:

DIGITAL SELF-TEST

SW2 'ON'
SW3 'OFF'
SW4 'OFF'
In this setting, a 1.8 degree motor continuously turns 5 revolution clockwise and counter-clockwise at low, medium, and high speed.

ANALOG SELF-TEST

SW2 'OFF'
SW3 'OFF'
SW4 'OFF'
In this setting, the motor's rate of acceleration is set by TRIM3, its velocity is set by TRIM5. The motor will move 5 revolutions in either direction before reversing.

STEP 5: SELECT STEP SIZE

The GM215 can move in full-step, half-step or 10-microstep increments.

FULL-STEP

SW3 'ON'
SW4 'OFF'
Every step pulse will move a 1.8 degree motor 1.8 degrees. The motor will move with 10-microstep smoothness which greatly limits low speed vibration.

HALF-STEP

SW3 'OFF'
SW4 'ON'
Every step pulse will move a 1.8 degree motor 0.9 degrees. The motor will move with 10-microstep smoothness to limit low speed vibration.

10-MICROSTEP

SW3 'ON'
SW4 'ON'
Every step pulse will move a 1.8 degree motor 0.18 degrees. The motor will move with 320-microstep smoothness which makes the motor's motion continuous instead of step-wise even at very low speeds (less than 1 full-step per second).

STEP 6: SELECT STANDBY CURRENT REDUCTION

Standby Current Reduction is a method of reducing motor heating while a motor is idle and not moving. This is accomplished reducing motor current to 70% of the set value if this setting is enabled. The only adverse effect is the motor's holding torque is reduced to about 75% of its nominal value. If the motor has a back-driving load such as holding up a weight against gravity, this selection may not be advisable.
When enabled, the current reduction goes into effect 1 second after the last step pulse is received. The motor stays in this state until a new step pulse sent, at which time full current is restored very quickly.

SW2 'ON' enables current standby. The current is reduced while a motor is idle.
SW2 'OFF' disables current standby. An idle motor will stay at full current.

THIS COMPLETES THE SWITCH SETUP

CN2 CONNECTOR ASSIGNMENTS

Connector CN2 terminals 6 through 12 are unused in the Step Motor Drive mode. Terminals 1, 2 and 3 are common cathode opto-isolated inputs with 200 Ohm current limit resistors. The inputs work with 2.5V, 3.3V and 5V logic levels. Logic 1 input current is 2 mA. The output is an open collector opto-isolator that has a 10 mA current sink rating.

Terminal	Function	I/O
1	DISABLE	INPUT
2	DIRECTION	INPUT
3	STEP	INPUT
4	COMMON	EXTERNAL GROUND
5	FAULT	OUTPUT

DISABLE (TERMINAL 1)

The motor drive is ENABLED when this input is unused or has a logic 0 applied. The motor drive is DISABLED when this input has a logic 1 applied. When DISABLED, the motor current goes to zero, there is no switching activity on the motor outputs and the motor free-wheels (detent torque). The motor position is restored if no step pulses have been sent while disabled.

DIRECTION (TERMINAL 2)

The state of this input determines the direction a motor will move when a step pulse is received. The DIRECTION logic level must be stable 250ns before the active edge of the step pulse.

STEP (TERMINAL 3)

A positive edge on this input (logic 0 to logic 1) causes the motor to move one increment of motion. The minimum logic 1 time is 1 microsecond and the minimum logic 0 time is 3 microseconds.

COMMON (TERMINAL 4)

This is the ground terminal for the DISABLE, DIRECTION and STEP inputs and the FAULT output. It must go to the ground terminal of the controller that generates these inputs.

FAULT (TERMINAL 5)

This output goes to a logic 1 when the drive goes into protective shutdown because of over-voltage, over-current or over-temperature. Once the cause for the FAULT is corrected, the FAULT output can be cleared by cycling the power supply or the DISABLE input.

END OF GM215 STEP MOTOR DRIVE MANUAL

GM215 MOTION CONTROLLER MANUAL

This manual covers the GM215 when it's used as a motion controller and motor drive. Go to the **GM215 MOTION CONTROLLER MANUAL** if the GM215 is used as a conventional STP/DIR input step motor drive.

SWITCH SETTINGS AND CONNECTOR WIRING

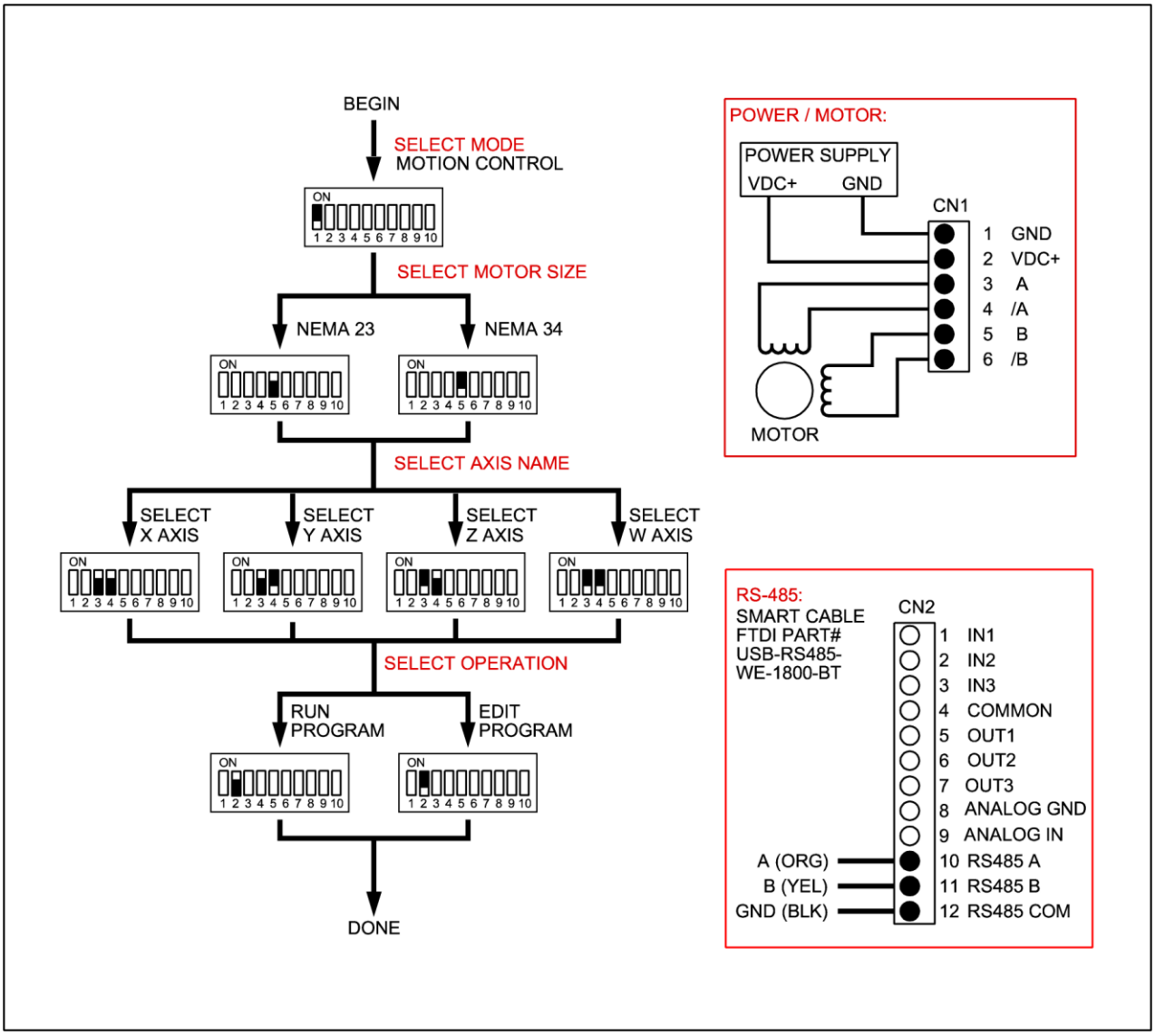


Figure 3.

GM215 SETUP FOR MOTION CONTROLLER MODE

CAUTION: The following switch settings and their function only applies to the Motion Controller Mode. The same switches have completely different functions in the Step Motor Drive mode. Turn the power supply 'OFF' and take care to set the switches to their correct settings when changing the operating mode.

STEP 1: SELECT MOTOR DRIVE MODE SW1 'OFF' Select motion controller mode operation.

STEP 2: SELECT MOTOR SIZE SW5 'ON' The motor is a NEMA-23 size or smaller.
SW5 'OFF' The motor is a NEMA-34 size or larger.

STEP 3: SELECT AXIS NAME The axis name tells a GM215 which commands and communications apply to it and which it can ignore.

X AXIS	SW3 'ON'	**Y AXIS**	SW3 'ON'	**Z AXIS**	SW3 'OFF'	**W AXIS**	SW3 'OFF'
	SW4 'ON'		SW4 'OFF'		SW4 'ON'		SW4 'OFF'

STEP 5: SELECT OPERATION The Motion Controller has 2 operating modes: RUN and EDIT.

RUN PROGRAM SW2 'ON'

In RUN PROGRAM mode, one or more G215s execute a user program stored in Flash ROM without requiring a computer connection. A computer connection can be used if it is necessary to monitor program execution. The GM215 inputs and outputs are used to coordinate motion with switches, sensors and other GM215s.

EDIT PROGRAM SW2 'OFF'

The EDIT PROGRAM mode is used to edit an existing user program or to write new user program. This mode requires a serial connection (RS-485) to a computer used to edit or write the program.

Program lines can be sent from the computer to the G215 for immediate execution. For instance, sending a command to 'home' an axis will result in the axis' step motor immediately moving the mechanism to the home location.

Once a user program is written or, a written program is modified in editing, the user program can be flashed to ROM on the target GM215 and/or stored to file on the computer.

THIS COMPLETES THE SWITCH SETUP

CN2 CONNECTOR ASSIGNMENTS

Terminals 1, 2 and 3 are opto-isolator LED anode inputs in series with 200 Ohm current limit resistors. The LED cathodes go to the COMMON terminal. The inputs work with 2.5V, 3.3V and 5V logic levels. Minimum logic 1 input current is 2 mA. Terminals 5 and 7 two opto-isolated collector outputs that have a 10 mA current sink rating and their emitters go to the COMMON terminal. Terminals 8 and 9 are for a third opto-isolated output whose collector and emitter are uncommitted.

Terminal	Name	Function
1	IN1	INPUT
2	IN2	INPUT
3	IN3	INPUT
4	COMMON	
5	OUT1	OUTPUT
6	OUT2	OUTPUT
7	OUT3	OUTPUT
8	ANALOG GND	ANALOG GND
9	ANALOG IN	ANALOG INPUT
10	RS485 A	SERIAL PORT
11	RS485 B	SERIAL PORT
12	RS485 COM	SERIAL PORT GROUND

IN 1 (TERMINAL 1)

This is a low-speed opto-isolated general purpose input. A logic '1' signal turns the input 'ON'. The signal ground is the COMMON terminal (term 4). At RUN mode its dedicated function is RESET.

IN 2 (TERMINAL 2)

This is a high-speed opto-isolated general purpose input. A logic '1' signal turns the input 'ON'. The signal ground is the COMMON terminal (term 4). Its dedicated function is the home switch input if the **HOME** command is used.

IN 3 (TERMINAL 3)

This is a high-speed opto-isolated general purpose input. A logic '1' signal turns the input 'ON'. The signal ground is the COMMON terminal (term 4). It has no dedicated function.

COMMON (TERMINAL 5)

This terminal is the signal ground for IN 1, IN 2, IN 3, OUT 1, OUT 2 and OUT 3 opto-isolators.

RS485 (TERMINALS 10, 11, 12)

These terminals are used by the RS-485 transceiver. The RS-485 COM terminal connects to the GM215 circuit ground through a 33 Ohm resistor used to limit ground loop currents. All GM215s using the RS-485 serial interface must share a common power supply ground. The A input has a 3K pull-up resistor to 3.3V while the B input has a pull-down 3K resistor to ground. These terminals aren't opto-isolated.

MULTI-AXIS POINT-TO-POINT MOTION

Point-to-point multi-axis motion is used when it does not matter what path is taken to a coordinate location. This is perfectly acceptable in many application because point-to-point motion takes the shortest possible time moving to a new location.

Each axis can use its own programmed accelerate, velocity and destination values for motion. The path taken to the destination probably won't be in a straight line because each axis' acceleration, velocity and destination can be different so each axis will take a different amount of time moving to the new location. All of the axis must finish moving before they can move to the next programmed location.

MULTI-AXIS VECTOR MOTION

Unlike point-to-point motion, a vector motion path is along a straight line from the last coordinate location (previous x,y,z) connecting to the next coordinate (next x,y,z). The rate of acceleration and velocity is independent of the vector direction. Oftentimes the coordinates are short line segments that, when concatenated, linearly approximate arbitrary 2D or 3D curves.

Vector motion requires all GM215s begin and finish executing each vector segment at precisely the same time and this requires that all GM215's microprocessor clocks be phase locked to the master x-axis clock. Besides communication tasks, the master x-axis GM215 uses the RS-485 serial bus to transmit a synchronizing signal to all slave axis GM215s.

For reason of simplicity, each axis is programmed with exactly the same user program. Each GM215 calculates the vector length from the coordinates stored in the program but only extracts the vector component that matches that motion controller's designated name. The vector component is then processed by a motion control algorithm and the results are sent to the motor drive section of the GM215. Each GM215 then drives its attached axis motor and all the axis motor's movements combine to reconstitute the vector as a 2D or 3D motion in the motor-driven mechanism.

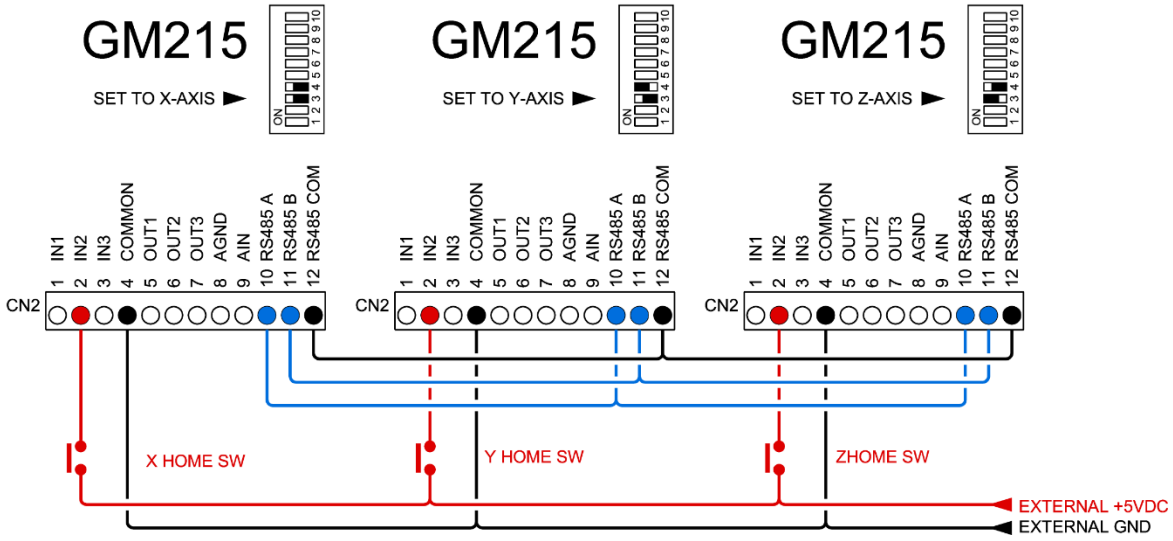


Figure 4: How to wire the HOME switches

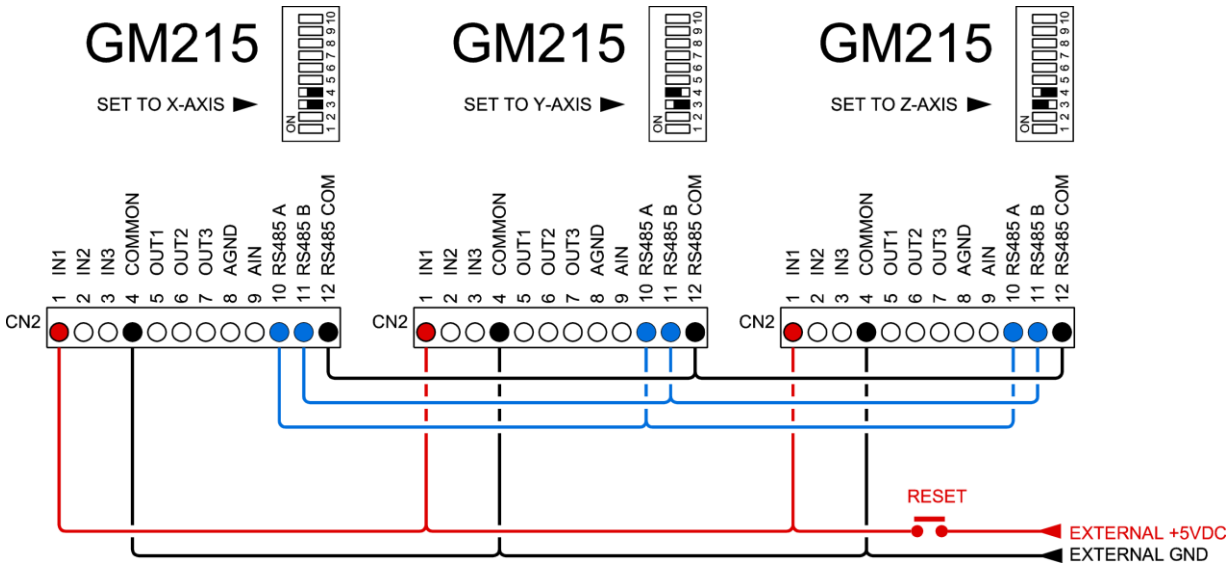
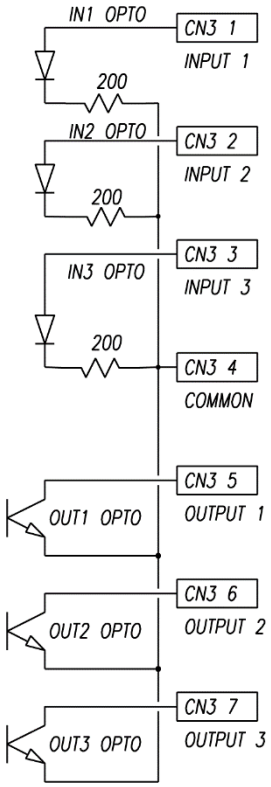


Figure 5: How to wire the RESET switch for RUN mode

I/O SCHEMATIC

The opto-isolator LED series current limit resistors are 200 Ohms on the IN1, IN2, and IN3 inputs. The input current is 17mA at +5A, 9mA at +3.3V and 2mA at +2.5V. The minimum operating input current for all inputs is 1.6mA. IN1 is a low-speed opto-isolator having a 50uS propagation delay. IN2 and IN3 are high-speed opto-isolators and have a 1uS propagation delay. OUT1, OUT2, and OUT3 are low-speed opto-isolators having a 50uS propagation delay.



GM215 COMMAND SET

The GM215 works as a multiple-axis motion controller when 2 or more drives are connected via its RS-485 interface. When used this way, **one GM215 must be named as the X drive (SW3 = ON, SW4 = ON) to make it the master drive**. Each of other drives must be set to a unique axis name (Y, Z, or W) using SW3 and SW4.

Once connected and named, the other slaved drives automatically synchronize themselves to the X-drive's microprocessor clock via sync pulse sent over the RS-485 interface. The drives communicate with each other and behave as if they were a single, 4-axis motion controller. All the drive's Flash ROMs are programmed with same user's application program; each drive executes only those commands that match the drive's name. This simplifies programming, editing and program maintenance because the drives are interchangeable. A single .bin file sent from the GeckoMotion application is written to all drives' Flash ROMs simultaneously.

Once a user's program is debugged and flashed to the drives, the drives can be put into RUN mode (SW1 = OFF, SW2 = ON) and the PC interface can be disconnected. The drives will execute the user's program from its non-volatile memory without a PC connection.

The drive's Flash ROM stores up to 65,536 lines of commands and all commands have fixed 2-word (32-bit) length. Appendix A shows how these commands are coded to this 2-word binary format used by the GM215. This is to allow a user to write their own GUI if they wish to do so. The RS-485 uses a standard UART set to 115,200 baud, 8-bit data, no parity and 1 stop bit.

Commands can be entered and debugged while the GM215 is in the EDIT PROGRAM mode (SW1, SW2 OFF). The GM215 must be connected to PC via its RS-485 interface while in the EDIT PROGRAM mode and the PC must be running the GeckoMotion application.

The commands have 3 main groups; Configuration commands, Motion commands and Program Flow commands:

CONFIGURATION COMMANDS:

CONFIGURE AXIS	Set the axis motor current and other parameters
ACCELERATION	Set axis rate of acceleration
VELOCITY	Set axis target velocity
ANALOG INPUTS	Switch the axis between digital and analog inputs
VECTOR AXIS	Combine 2 or more axis for vector motion
MOVING AVERAGE	Filter the axis motion using a moving average filter
LIMIT CW	Set the axis CW travel limit

MOTION COMMANDS:

MOVE	Move axis to an absolute or relative destination
HOME	Home the axis to a hardware switch location
JOG	Move the axis using external inputs
SPEED CONTROL	Operate the axis in velocity mode
POSITION ADJUST	Adjust the axis position using external inputs

PROGRAM FLOW COMMANDS:

GOTO	Go to a program-line, also Loop (4 nested loops allowed)
CALL	Call a subroutine and return (4 nested calls allowed)
IF THEN ELSE	If a condition is met then go to program-line 'n', else go to next program-line
WAIT	Wait a period of time, then go to next program-line

MISCELLANEOUS COMMANDS:

OUTPUT	Turn a hardware output ON or OFF	
COMPARE	Stores a variable used by the IF-THEN-ELSE command	
CHANGE SCALE	Change the motion coordinate scale	(future)
ROTATE	Rotate the axis coordinates by an angular value	(future)
TANGENT	Rotate an axis to point in the motion direction	(future)
MIRROR	Mirror the axis coordinates vertically or horizontally	(future)
ENCODER	Axis tracks a quadrature encoder	(future)

The GeckoMotion host program uses labels for program flow commands. This greatly eases the burden of writing and debugging the user program:

00067	**PREVIOUS COMMAND**	
00068	**IF Z INPUT 2 IS OFF GOTO label_1**	An IF command tests if the Z axis input 2 is off. If true, the program jumps to 'label_1:'
00069	**NEXT COMMAND**	If false, the program goes to the next command
----	**------**	
----	**------**	
----	**------**	
00234	**label_1:**	
00235	**SOME OTHER COMMAND**	Program jumped here because the Z axis input 2 is off.
----	**------**	

Note: See sample programs at pages 28 thru 30 for further clarification.

CONFIGURE AXIS **CONFIGURATION COMMAND**

Syntax: **a C**ONFIGURE: **i** AMPS, IDLE AT **p %** AFTER **s** SECONDS**<ENTER>**
Operands: **a** = X, Y, Z, W
CONFIGURE = configure axis command
0.0 <= **i** <= 7.0
00 <= **p** < 100
00.0 <= **s** =< 25.5
Operation: Sets the motor's operating parameters.
Type: The command settings are global.

Description: This command sets:
1. The selected axis motor phase current from 0 Amps to 7 Amps per phase in 100mA increments. Refer to the motor data-sheet for the correct current setting for motor being used.

2. Sets the motor's standby idle current while the motor is stopped to reduce motor heating. The motor standby current is the set percentage times the motor's set phase current. The drive also goes into recirculating mode switching while in idle to reduce motor eddy-current heating.

3. Sets the time delay before going into the idle mode after the motor stops. Motor current is restored to its full set value immediately after the motor must run again.

Example:

X CONFIGURE: 1.8 AMPS, IDLE AT 71% AFTER 2.5 SECONDS
X means the CONFIG command settings apply to the X axis motor.
CONFIGURE selects the CONFIG command.
1.8 AMPS is the motor phase current setting.
71 means reduce the motor phase current to 71% of the set AMPS value while the motor is stopped.
2.5 SECONDS is the delay time before current is reduced after the motor stops.

ANALOG INPUTS **CONFIGURATION COMMAND**

Syntax: **ANALOG INPUTS TO a, a, a, a <ENTER>**
Operands: **a** = axis **X** or **Y** or **Z** or **W**
Operation: Sets inputs to analog for selected axis.
Type: The command settings are global.

Description:
This command sets analog voltage inputs values for acceleration, velocity and position settings for the selected axis.

Example:

ANALOG INPUTS TO X <ENTER>

ANALOG INPUTS TO Z, X <ENTER>
ANALOG INPUTS is the ANALOG INPUT command
Z includes the Z axis for analog inputs for Acceleration, Velocity and Position values.
, means another axis is to be included.
X includes the X axis for analog inputs for Acceleration, Velocity and Position values.
<ENTER> completes the command. The Y and W axis weren't included so will use digital values for Acceleration, Velocity and Position in commands that require these settings.

VECTOR AXIS **CONFIGURATION COMMAND**

Syntax: **VECTOR AXIS ARE a, a, a, a <ENTER>**
Operands: **a** = axis **X** or **Y** or **Z** or **W**
Operation: Associates which axis are to be combined for vector motion.
Type: The command settings are global.

Description:
This command selects which axis will be combined for vector motion. Vector velocity is the same regardless of the vector's direction, all associated axis motion begins and ends at the same time and the path taken will be a straight line connecting the origin and destination coordinates.

Example:

VECTOR AXIS ARE X, Y, W <ENTER>
VECTOR AXIS ARE is the VECTOR AXIS command
X means include the X axis.
, is the delimiter indicating another axis is to be included.
Y means also include the Y axis.
, means another axis is to be included.
W means also include the W axis.
<ENTER> indicates the command is finished.

LIMIT CW **CONFIGURATION COMMAND**

Syntax: **a LIMIT CW n <ENTER>**
Operands: **a** = axis **X** or **Y** or **Z** or **W**
0 =< **n** <= 16,777,215
Operation: Sets the axis clockwise travel limit from the home position.
Type: The command settings are global.

Description:
This command sets the maximum distance for any motion away from the HOME position. Its function is to prevent damage to a mechanism if the axis is inadvertently commanded to move beyond the mechanism's safe limits. This can occur if a programming error is made or an axis is jogged past this limit if the limit is exceeded. The motor is decelerated to a stop and locked. Use software reset (press E-STOP button in GUI) or hardware reset (IN1 in RUN mode) to unlock the motor.

This command is optional. If the command isn't used, the default value is 16,777,215.

Example:

Z LIMIT CW 987654 <ENTER>
Z means the Z axis is selected
LIMIT CW means the LIMIT CW command
987654 sets the axis travel limit 987,654 increments of motion away from the home location.
<ENTER> indicates the command is complete.

ZERO OFFSET **CONFIGURATION COMMAND**

Syntax: **a ZERO OFFSET n <ENTER>**
Operands: **a** = axis **X** or **Y** or **Z** or **W**
0 <= **n** <= 8,388,607
Operation: Sets the axis 'zero' position CW from the HOME switch.
Type: The command settings are global.

Description:
The command value is used by the HOME command to automatically move the axis CW from the HOME switch location a distance equal to the ZERO OFFSET value. If this command isn't used, the axis will be located at the HOME switch after the HOME command.

Example:

Y ZERO OFFSET 12345 <ENTER>

Y means the Y axis is selected
ZERO OFFSET means the ZERO OFFSET command
12345 means move 12,345 increments of motion CW from the HOME switch.
<ENTER> indicates the command is complete.

ACCELERATION **CONFIGURATION COMMAND**

Syntax: **a ACCELERATION n <ENTER>**
Operands: **a** = axis **X** or **Y** or **Z** or **W**
0 <= **n** <= 32767
Operation: Sets the axis rate of acceleration.
Type: The command settings are global.

Description:
This command sets the motor's rate of acceleration for every command that causes the motor move. This setting can be changed at any time, even while the axis is in motion without affecting the axis destination. If the ANALOG INPUT command includes this axis, then this set value is ignored and the analog value is used during axis motion. If the ANALOG INPUT command later excludes this axis, then the set value for acceleration in this command will apply.

Example:

Y ACCELERATION 12345 <ENTER>

Y means the Y axis is selected
ACCELERATION means the ACCELERATION command
12345 sets the acceleration rate to 12,345.
<ENTER> indicates the command is complete.

During acceleration the acceleration value is added to the axis current velocity register and the sum is output to the axis speed generator. Once the sum equals or exceeds the axis set velocity value, the set velocity is output to the speed generator instead. The sum is updated 1,000 times a second. Time to speed in milliseconds = VELOCITY value / ACCELERATION value

---

VELOCITY **CONFIGURATION COMMAND**

Syntax: **a VEL n<ENTER> (or a VELOCITY n<ENTER>)**
Operands: **a** = axis **X** or **Y** or **Z** or **W**
VEL = VELOCITY command
0 <= **n** <= 32767
Operation: Sets the axis velocity limit.
Type: The command settings are global.

Description:
The motor will accelerate at a rate set by the ACCELERATE command to a speed set by the VELOCITY command. If the VELOCITY value is changed while the motor is running, the motor will accelerate or decelerate to the new VELOCITY value. If VELOCITY or ACCELERATION is changed while the axis is in motion, the axis will still reach the programmed destination.

Example:

X VELOCITY 12345 <ENTER> (or X VEL 12345 <ENTER>)

X means the X axis is selected
VEL means the VELOCITY command
12345 sets the velocity limit to 12,345.
<ENTER> indicates the command is complete.

MOVE **MOTION COMMAND**

Syntax: **asn, asn, asn, asn<ENTER>**
Operands: **a** = axis **X** or **Y** or **Z** or **W**
s = **+** or **–** or **<SP>**
0 =< **n** <=16,777,215 for **s** = **<SP>**
0 =< n <=8,388,607 for s = + or –
Operation: Moves the listed axis to positions set by the n value.
Type: The command settings are local.

Description:
Because this command is likely to be used far more frequently than any other command, the number of keystrokes to enter this command are kept to an absolute minimum.

SINGLE AXIS MOVE
This command causes the axis to accelerate at the ACCELERATION value rate, reach a speed set by the VELOCITY value and decelerate to a stop at a position set by the **n** destination value. These values can be changed even while the axis is in motion, the axis will stop at the expected destination.

Example:

Z 10000 <ENTER>
Z means the Z axis is selected
<SP> means this is an absolute move
10000 means move to a location that is 10,000 increments of motion from the zero position.
<ENTER> indicates the command is complete.

X+1234 <ENTER>
X means the X axis is selected
+ means this is a relative move in the clockwise direction
1234 means move 1234 increments of motion CW from the present location.
<ENTER> indicates the command is complete.

Y-10 <ENTER>
Y means the Y axis is selected
- means this is a relative move in the counter-clockwise direction
10 means move 10 increments of motion CCW from the present location.
<ENTER> indicates the command is complete.

The axis position is continuously compared to the limit value set by the **LIMIT CW** command. Any move that is beyond that limit results in the axis decelerating to a stop. No further motion command is permitted. Use software reset (press E-STOP button in GUI) or hardware reset (IN1 in RUN mode) to unlock the motor.

Warning: User should use an appropriate value of n when using this command.

For example: x +1000 (move 1000 steps CW)
x -2000 is illegal and should be strictly forbidden. (x -1000 is OK)

MULT-AXIS VECTOR MOVES
If an axis is included in **VECTOR AXIS** command, it will combine with the other included axis to generate a straight-line vector path to the destination. If the axis is not included, it will act independently and use its own ACCELERATE and VELOCITY values to reach the destination set by the **n** value.

X+4000, Y-3000, W 5000 <ENTER>
X means the X axis is selected
+ means this is a relative move in the clockwise direction
4000 means move the X axis 4000 increments of motion CW from the present location.
, indicates another axis is to be included
Y means the Y axis is selected
- means this is a relative move in the clockwise direction

3000 means move the Y axis 3000 increments of motion CCW from the present location.
<ENTER> indicates the command is complete.

HOME **MOTION COMMAND**

Syntax: **HOME a, a, a, a <ENTER>**
Operands: **HOME** = HOME command
a = axis **X** or **Y** or **Z** or **W**
d = **,** or **<ENTER>**
Operation: Moves the listed axis to the HOME switch location.
Type: The command's OFFSET value is global.

Description:
The **HOME** command moves the selected axis CCW towards a HOME switch connected to **IN2**. The axis acceleration rate is the **ACELERATE** command value to a velocity set by the **VELOCITY** command value. When the HOME switch closes, the axis decelerates to a stop, reverses direction to CW and runs at a slow speed while the HOME switch is closed. When the HOME switch opens, an automatic CW move from the HOME switch position is then made. The distance moved is the axis' **ZERO OFFSET** value. When this automatic move finishes, the axis position register is cleared. If no **ZERO OFFSET** value has been entered, then its default value is zero.

Once the **HOME** command finishes, the user program advances to the next command line. Any subsequent motion command that moves the axis to a position less than zero (the OFFSET position) or greater than the **LIMIT CW** command value should not be allowed.

Example:

HOME X <ENTER>
HOME is the HOME command
X is the selected axis
<ENTER> means the command entry is finished

Multiple axis can be homed simultaneously to save time spent in this command. The X, Y and Z axis will home at the same time if the command was written as:

HOME X, Y, Z <ENTER>
HOME is the HOME command
X is the selected axis
, means more axis will be included
Y means the Y axis is included
, means more axis will be included
Z means the Z axis is included
<ENTER> means the command entry is finished. The previously set axis OFFSET values will be used.

JOG **MOTION COMMAND**

Syntax: **JOG a**
Operands: **a** = axis **X** or **Y** or **Z** or **W**
Operation: Move the axis using switches or trimpots.
Dependence: **ANALOG INPUT** command.
Type: The command requires a hardware exit.

Description:
If the **ANALOG INPUT** command doesn't include the axis, the **JOG** command uses **IN2** as the JOG CW switch input and **IN3** as the JOG CCW switch input. Pushing the CW or CCW switch causes the axis to accelerate at the ACCELERATE command value to a velocity set by the VELOCITY command value. The axis decelerates to a stop when the jog switches are released. The axis position is continuously compared to the **LIMIT CW** command value and the home OFFSET position value limits. Any jog switch command that moves the axis out-of-bounds results in the axis decelerating to a stop. Then only jog commands that move the axis back into bounds are allowed.

If the **ANALOG INPUT** command includes the axis, then **TRIM4** is the **JOG** command input. When **TRIM4** is less than 25% the motor will travel CCW. When **TRIM4** is more than 75% the motor will travel CW. When **TRIM4** is between 25% and 75% the motor will stop. The axis out-of-bounds response is the same as for jog switch inputs. **TRIM3** is used to set JOG acceleration, and **TRIM5** is used to set JOG velocity.

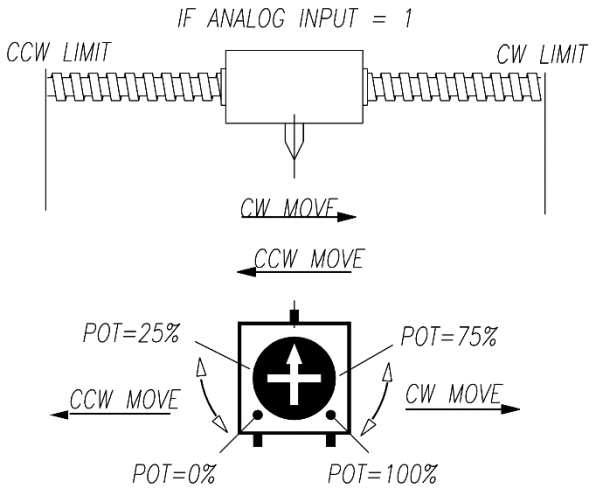
Example:

JOG X

X means the X axis is selected
JOG is the JOG command
<ENTER> means the command entry is complete

Once invoked, the **JOG** command cannot terminate on its own because it is an open ended command. A momentary logic '1' on **IN1** exits the **JOG** command. A simultaneous momentary logic '1' on **IN2** and **IN3** (by pressing SW2 and SW3 at the same time) can also exit the **JOG** command. The user program then advances to the next command.

If **JOG** is used in a 2 axis system, a switch-type or potentiometer-type joystick can be used. Apply hardware exit on both drive to exit this command.



SPEED CONTROL **MOTION COMMAND**

Syntax: **a SPEED CONTROL sn <ENTER>**
Operands: **a** = **X** or **Y** or **Z** or **W**
s = **+** or **-**
0 <= **n** <= 32767
Operation: The axis runs continuously at set speeds.
Dependence: **ANALOG INPUT**, **ACCELERATE** and **VELOCITY** command values.
Type: The command requires a hardware exit.

Description:
This is special 'canned' command that runs the axis continuously at a set speed. Optionally, Stop/Run and CW/CCW travel distance limit switches can be used with **IN1**, **IN2** and **IN3 (use momentary switches only)**. The **ANALOG INPUT** command value determines the source of acceleration and velocity values if the axis is included. **TRIM5** sets the CW velocity and **TRIM4** sets the CCW velocity. Otherwise the **VELOCITY** command values set the axis acceleration rate and the velocity respectively.

Example:

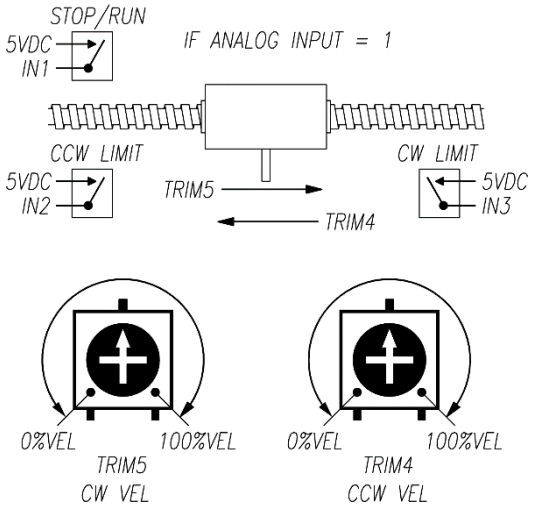
Z SPEED CONTROL +12345 <ENTER>
SPEED CONTROL is the SPEED CONTROL command
Z means Z is the selected axis
+ means the motor direction is CW.
12345 means move the axis at a speed of 12345
<ENTER> means the command entry is finished

TRIM5 and **TRIM4** multiply the velocity value from 0 to 1 to set the CW and CCW velocities.

OPTIONAL SWITCH INPUTS (use momentary switches only)
If limit switches are used, **IN2** is the CCW travel distance limit, **IN3** is the CW travel distance limit and **IN1** is the Start/Stop switch input. The initial motor direction is set by the **SPEED CONTROL** command sign operand. The motor will accelerate to speed in the CW direction if the sign is '**+**'. The axis moves in the initial direction until it encounters a limit switch. The motor then decelerates to a stop and then accelerates to speed in the opposite direction. This process continues indefinitely until the command is terminated.

At any time the axis can be decelerated to a stop by applying a logic '1' to **IN1**. Releasing **IN1** (logic '0') results in the axis accelerating back to speed in the same direction it was going before.

Once invoked, the **SPEED CONTROL** command cannot terminate on its own because it is an open ended command. A simultaneous momentary logic '1' on **IN2** and **IN3** (by pressing SW2 and SW3 at the same time) exits the **SPEED CONTROL** command. The user program then advances to the command.



POSITION ADJUST **CONFIGURATION COMMAND**

Syntax: **a POSITION ADJUST +/- n <ENTER>**
Operands: **a** = **X** or **Y** or **Z** or **W**
0 =< **n** <= 32,767
Operation: Adjusts the axis position using an analog voltage.
Dependence: None
Type: The command requires a hardware exit.

Description:

This command uses **TRIM5** to adjust the axis position within a CW / CCW range set by the **n** value. The TRIM5 setting adjusts the axis position over a +/- 100% range of the **n** value; the adjustment is 0% when TRIM5 is at the mid-point position.

Warning: Home (CCW limit) and CW limit will not be checked. User should use appropriate values of n when using this command.

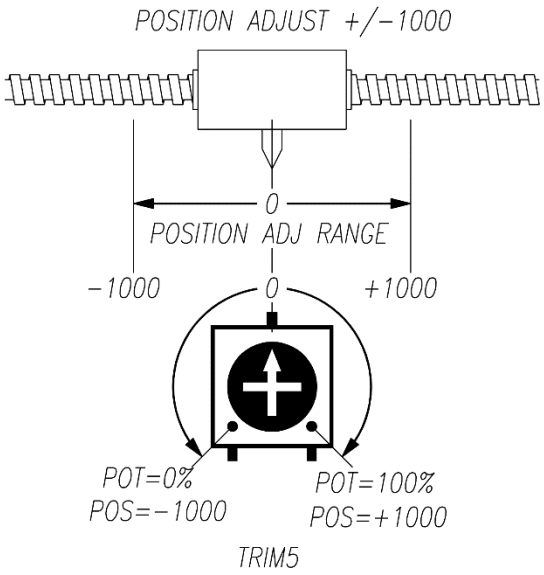
Example:

X POSITION ADJUST +/- 1000 <ENTER>

X means X is the selected axis.
POSITION ADJUST +/- means the POSITION ADJUST command.
1**000** means set the full-scale range to +/- 1,000 increments of motion.
<ENTER> indicates the command entry is complete.

In this example, 2,000 is the number of steps required to turn the motor 1 full revolution. Turning TRIM5 from zero to full scale will proportionately adjust the motor from 1 revolution CCW of its commanded position to 1 revolution CW of its commanded position.

If POSITION ADJUST is used in a 2 axis system, a potentiometer-type joystick can be used to adjust the x,y position. An example of its utility would be to index a sample underneath a microscope, use joystick to examine the sample.
A momentary logic '1' must be applied to IN1 on the axis to exit this command.



PROGRAM FLOW COMMANDS:

Program flow commands break the normal sequential order of program flow by forcing an out of sequence location of the next command. Commands then execute sequentially again starting at the new location. The main program flow commands are unconditional jumps and loops (**GOTO**), calls and returns from subroutines (**CALL**), If-Then-Else conditional jumps (**IF**) and wait loops (**PAUSE**).

GOTO **PROGRAM FLOW**
COMMAND

Syntax: **GOTO k, LOOP n TIMES <ENTER>**
Operands: k = **<LABEL>**
0 <= **n** <= 255
Operation: Go to label name location in the user program.
Dependence: None
Type: The command value is local.

Description:
This command jumps to the label name location and resumes executing the program from there. Additionally, the command can jump to a label location a set number of times before the command is ignored (LOOP **n** TIMES).

Example:
GOTO abcd <ENTER>
GOTO is the GOTO command
abcd means jump to program a location named 'abcd:'
<ENTER> indicates the command entry is done

Example:
GOTO abcd, LOOP 8 TIMES <ENTER>
GOTO is the GOTO command
abcd means jump to program a location named 'abcd:'
, indicates looping is required
8 means LOOP 8 TIMES through this command before going to the next program line after this command
<ENTER> indicates the command entry is done

In the below example, **SOME COMMAND** executes at line 01007 and then the GOTO command at line 01008. The GOTO loop count decrements and if it's not zero, the program jumps to '**abcd:**'. This repeats 5 times until the LOOP count is zero. On the zero count the LOOP counter is set to 5 again, the GOTO jump is ignored and the program advances to **NEXT COMMAND** on line 01009.

```
01006    abcd:
01007       SOME COMMAND
01008       GOTO abcd, LOOP 5 TIMES
01009       NEXT COMMAND
```

Nested loops:
Nested loops are loops within loops. An example would be some process that has to be repeated for 'y' rows and 'x' columns. In the example below, there are 5 rows and 10 columns. The program loops through line 01004 to line 01010 ten times. Lines 01006 and 01008 are repeated five times for every pass through the first loop. Lines 01007 and 01008 get repeated 50 times.
Note: Up to 4 nested loops are allowed.

```
01004    outer_loop:
01005       SOME OTHER COMMAND
01006    inner_loop:
01007       SOME COMMAND
01008       GOTO inner_loop, LOOP 5 TIMES
01009       NEXT COMMAND
01010       GOTO outer_loop, LOOP 10 TIMES
01011       ANOTHER COMMAND
```

CALL **PROGRAM FLOW**
COMMAND

Syntax: **CALL k <ENTER>**
Operands: k = <LABEL>
Operation: Calls a function. Returns to the program line after this one when finished.
Dependence: None
Type: The command value is local.

Description:
This command jumps from the current command line to a command line specified by the value **n**. The program continues from that line until the function is finished. The last command line in the function must be **CALL** which causes a return to the command line immediately after the one which called the function.
Note: Up to 4 nested function calls are allowed.

Example:

CALL function_name <ENTER>
CALL is the CALL command
function_name means the CALL function begins at a program location labeled as '**function_name:**'
<ENTER> indicates the command entry is done

The following example shows how nested CALLs are used:

```
00198     COMMAND
00199     CALL func_1     Call a subroutine beginning at line 758.
00200     COMMAND         ←Return from func_1 here.
00201     COMMAND
-------   -------
00311  func_2:
00312     COMMAND         ← CALL func_2 from line 00760 from inside func_1 calls another function starting on this command line.
00313     COMMAND
00314     RETURN          Return. Subroutine func_2 is finished.
--------  -------
00757  func_1:
00758     COMMAND         ← CALL func_1 from line 00199 calls a subroutine starting on this command line.
00759     COMMAND
00760     CALL func_2     Call another subroutine beginning at line 312. This call is from inside the CALL 758 function.
00761     COMMAND         ←Return from func_2 here.
00762     RETURN          Return. Subroutine func_1 is finished
```

RETURN COMMAND **PROGRAM FLOW**

Syntax: **RETURN <ENTER>**
Operands: None
Operation: Returns to the program line after the CALL command line.
Dependence: None
Type: The command value is local.

Description:
This command is used to end a CALL function. The program counter jumps to the next program line after the CALL command line.

Example:

RETURN <ENTER>
RETURN means this a RETURN command.
<ENTER> indicates the command entry is completed

WAIT COMMAND **PROGRAM FLOW**

Syntax: **WAIT nn.nnn SECONDS <ENTER>**
Operands: 0 <= **nn.nnn** <= 65.535
Operation: Pauses program execution for a period of time
Dependence: None
Type: The command value is local.

Description:
This command inserts a time delay on **n** milliseconds to pause the user program.

Example:

WAIT 2.500 SECONDS <ENTER>
WAIT means this is a PAUSE command.
2.500 means wait for 2,500 milliseconds (2.5 seconds)
<ENTER> indicates the command entry is done

IF-THEN-ELSE **PROGRAM FLOW COMMAND**

Syntax: **IF a t IS c GOTO k <ENTER>**
Operands: **a** = **X** or **Y** or **Z** or **W** axis name
t = **IN1** or **IN2** or **IN3** or **RDY** or **ERR** single-bit variable test or **VEL** or **POS** or **VIN** multiple-bit variable test
c = **ON** or **OFF** single-bit test or **>** or **=** or **<** multiple-bit variable test against COMPARE
k = **<LABEL>**
Operation: IF a test is true, THEN go to the label name program location, ELSE go to the next program line.
Dependence: None
Type: The command value is local.

Description:
This command is a conditional jump. A single bit variable **i** is tested for ON or OFF. If true, then the next command line location is at the labeled name. Else the next command line is executed. Multiple-bit variables VELOCITY, POSITION and VIN are compared against the COMPARE value (see COMPARE command). VIN is a 1-byte analog to digital conversion of a 0V to 5V input to the GM215. VEL is a 2-byte value of the axis's current velocity and POS is a 3-byte value of the axis' current position.

Examples:

IF X IN 3 IS ON GOTO someplace <ENTER>
IF means this is an IF-THEN-ELSE command.
X means test an X axis input or variable.
IN3 means test general purpose input number 3.
ON means the test is for an ON state.
someplace is the GOTO label if the test is true.

IF Z VEL IS > GOTO vel_is_bigger <ENTER>
IF means this is an IF-THEN-ELSE command.
Z means test an Z axis input or variable.
VEL means the axis current velocity.
> means test if velocity is greater than the COMPARE value.
vel_is_bigger is the GOTO label if the test is true.

IF W VIN IS < GOTO low_voltage <ENTER>
IF means this is an IF-THEN-ELSE command.
W means test an W axis input or variable.
VIN means test the axis analog input voltage VIN.
< means test VIN to determine if it is less than the COMPARE value.
low_voltage is the GOTO label if the test is true.

An input can be continuously polled (tested) for an input state. If the input test is false, the input test is repeated until the result is true. When true, the user program advances to the next program line.

A HOME command is required when a switch connected to the X axis IN1 turns ON and the program waits until this is true. Assume the code to do this starts at command line 00123.

PGM LINE	COMMAND	COMMENT
00122	**wait_for_switch:**	Label name
00123	**IF X IN1 IS OFF GOTO wait_for_switch**	While the X axis IN1 is OFF the command THEN keeps retesting IN1
00124	**HOME X**	← ELSE if you are here, IN1 was ON. Home the axis.
00125	**NEXT COMMAND**	Do something after the axis has homed

If it's undesirable to stall the program while waiting for IN1 to be ON and it can be tested later, the IF command can be written as:

PGM LINE	COMMAND	COMMENT
00122	**IF X IN1 IS OFF GOTO switch_is_off**	Test the X axis for IN1 is OFF
00123	**HOME X**	← ELSE if you are here, IN1 was ON. Home the axis.
00124	**switch_is_off:**	Label name
00125	**NEXT COMMAND**	Continue with the program but have it loop through PGM LINE 00122 again.

Assume X axis output 3 must be turned 'on' if the Z axis voltage on VIN is between 2.5V and 3.0V.

PGM LINE	COMMAND	COMMENT
00455	Z COMPARE VALUE154	256 times 3.0V divided by 5.0V
00456	IF Z VIN > GOTO out3_off	GOTO label **out3_off** if VIN is greater than 3V.
00457	Z COMPARE VALUE 128	256 times 2.5V divided by 5.0V
00458	IF Z VIN > GOTO out3_on	GOTO label **out3_on** if VIN is greater than 2.5V.
00459	out3_off:	Label name
00460	X OUT 3 OFF	Turn X axis output 3 off.
00461	X GOTO skip_line	GOTO label **skip_line**
00462	out3_on:	Label name
00463	X OUT 3 ON	Turn X axis output 3 on.
00464	skip_line:	Label name
00465	NEXT COMMAND	Continue with the program

The following is a partial list of Boolean operations on 2 and 3 inputs using the **IF** command. They are offered as a template to the user from which other, not listed logical operations can be formed:

AND2

```
IF X IN1 IS OFF GOTO false
IF X IN2 IS OFF GOTO false
SOME COMMAND (true)
false:
SOME OTHER COMMAND
```

AND3

```
IF X IN1 IS OFF GOTO false
IF X IN2 IS OFF GOTO false
IF X IN3 IS OFF GOTO false
SOME COMMAND (true)
false:
SOME OTHER COMMAND
```

XOR2

```
IF X IN1 IS ON GOTO next
IF X IN2 IS ON GOTO true
false:
SOME COMMAND
next:
IF X IN2 IS ON GOTO false
true:
SOME OTHER COMMAND
```

OR2

```
IF X IN1 IS ON GOTO true
IF X IN2 IS ON GOTO true
false:
SOME COMMAND
true:
SOME OTHER COMMAND
```

OR3

```
IF X IN1 IS ON GOTO true
IF X IN2 IS ON GOTO true
IF X IN3 IS ON GOTO true
false:
SOME COMMAND
true:
SOME OTHER COMMAND
```

AND-OR

```
IF X IN 1 IS OFF GOTO +3
IF X IN 2 IS OFF GOTO +2
→ (IN1 & IN2) | IN3 is true
IF X IN3 IS ON GOTO -1
→ (IN1 & IN2) | IN3 is false
```

NAND2

```
IF X IN1 IS ON GOTO false
IF X IN2 IS ON GOTO false
→ NAND2 is true
→ NAND2 is false
```

NOR2

```
IF X IN1 IS OFF GOTO false
IF X IN2 IS OFF GOTO false
→ NOR2 is false
→ NOR2 is true
```

OR-AND

```
IF X IN1 IS ON GOTO false
IF X IN2 IS OFF GOTO false
IF X IN3 IS OFF GOTO false
→ IN1 | (IN2 & IN3) is true
→ IN1 | (IN2 & IN3) is false
```

MUX (2 INPUT / 1 OUTPUT MULTIPLEXER)

```
IF XIN3:+2; (MUX A/B SELECT IS IN3)
IF XIN1:+2; (MUX A IN IS IN1)
→ MUX OUT IS TRUE
IF /XIN2:-1; (MUX B IN IS IN2)
→ MUX OUT IS FALSE
```

OUTPUT **MISCELLANEOUS COMMAND**

Syntax: **a OUT n c <ENTER>**
Operands: **a** = **X** or **Y** or **Z** or **W** axis name
n = **1** or **2** or **3**
c = **ON**, **OFF, BR, RS, ER**
Operation: Outputs OUT1 or OUT2 or OUT3
Dependence: None
Type: The command value is local.

Description: Turns a hardware output ON or OFF

Examples:

X OUT 3 ON <ENTER>
X means the X axis is selected.
OUT is the output command.
3 is the hardware output number 3.
ON means turn this output ON.
<ENTER> means the command entry is complete.

Y OUT 1 BR <ENTER>
BR is Busy/Ready status.
Output1 of Y axis is set to reflect Busy/Ready status.

Z OUT 2 RS <ENTER>
RS is the R/S status.
Output2 of Z axis is set to reflect R/S status.

W OUT 3 ER <ENTER>
ER is the Error status.
Output3 of W axis is set to reflect ER status.

COMPARE **MISCELLANEOUS COMMAND**

Syntax: **a COMPARE VALUE n <ENTER>**
Operands: **a** = **X** or **Y** or **Z** or **W** axis name
0 =< **n** <= 16,777,215
Operation: Stores the value n to the COMPARE register
Dependence: None
Type: The command value is global.

Description: This command is used in conjunction with the IF-THEN-ELSE command when a variable has to be compared against a stored COMPARE value

Example:

X COMPARE VALUE 32767 <ENTER>
X means the X axis is selected.
COMPARE VALUE is the COMPARE command.
32767 is the value to be stored in the COMPARE register.
<ENTER> means the command entry is complete.

The following sample programs can be compiled and run in edit mode without any errors:

Example 1: this program will test all commands

```
main:
   call     xconfig              ;Configure X axis (xconfig is at the end of this program)
   call     yconfig              ;Configure Y axis (yconfig is at the end of this program)

start:

;Test HOME, MOVE and POSITION ADJUST command

   home x, y                    ;return home first
   x +4000, y +4000             ;move X and Y to position 4,000 CW
   x -2000                      ;move X CCW 2,000 steps (to position 2,000)
   x 3000, y 3000               ;absolute move X and Y to position 3,000
   x position adjust +/-2000  ;Turn TRIM5 to travel back and forth between position 1,000 and 5,000 (3,000 +/-2,000)
                                ;A momentary logic '1' must be applied to IN1 to exit this command.
;Test JOG, SPEED

   jog x                        ;Toggle SW-IN2 or SW-IN3 to move CCW or CW.
                                ;a momentary logic '1' must be applied to IN1 to exit this command.
   analog inputs to x           ;prepare to use TRIM4 to jog instead of SW-IN2 & SW-IN3
   jog x                        ;Turn TRIM4 to jog until limits
                                ;a momentary logic '1' must be applied to IN1 to exit this command.
   x speed control 1000         ;use momentary switches for IN1, IN2, IN3 to proceed this test.
                                ;SW1 for Stop/Run, SW2 for CCW limit and SW3 for CW limit.
   analog inputs to x           ;now prepare to use TRIM4 & TRIM5 to control the speed
   x speed control 1000         ;Use TRIM4 for CCW & TRIM5 for CW speed control
                        ;a momentary logic '1' must be applied to IN2 & IN3 to exit this command (press SW2 & SW3 at the same time).
;Test IF, GOTO, OUT & WAIT

   x out 1 on                   ;note: all outputs are open collector
   x out 2 on
   x velocity 8000              ;set velocity smaller than compare value
   x compare value 8001
TestIf1:
   if x vel is < goto TestIf2   ;will go to TestIf2 because it is true
   x -10000                     ;move back 10,000 steps
   x out 1 off                  ;turn off output 1
TestIf2:
   x +5000
   goto TestIf2, loop 3 times   ;will do this loop 3 times
   x out 2 off                   ;turn off output 2
   wait 5.0 seconds             ;wait for 5 seconds
   x -10000

;Test VECTOR

   vector axis are x,y          ;group X axis and Y axis together
   x velocity 8000              ;set different velocities for testing
   y velocity 4000

Lvector:
   x+10000, y+10000              ;X and Y axis move CW 10,000 steps
   x-10000, y-10000             ;X and Y axis move CCW 10,000 steps
   goto Lvector                 ;stay in this loop for ever

 End:
   goto End
```

```
xconfig:
   x configure: 0.8 amps, idle at 76% after 2.5 seconds
   x limit cw 90000    ;set CW limit for safe
   x zero offset 1000  ;set the offset if needed
   x acceleration 32   ;set the initial acceleration
   x velocity 8000     ;set the initial velocity
   return

yconfig:
   y configure: 0.8 amps, idle at 75% after 2.5 seconds
   y limit cw 80000
   y zero offset 1000
   y acceleration 32
   y velocity 8000
   return
  ;EOF
```

Example 2: this program will test JOG, SPEED CONTROL, POSITION ADJUST, and draw a square

```
 Main:
   call      xconfig   ;Configure X axis (xconfig is at the end of this program)
   call      yconfig   ;Configure Y axis

Start:

   home x, y                    ;return home first
   x +10000, y +10000           ;move X and y to position 10,000 CW

;Test JOG command: JOG Axis

   jog x                        ;toggle SW2 (IN2) or SW3 (IN3) to move CCW or CW until limits.

   analog inputs to x           ;prepare to use TRIM4 to jog instead of SW2 & SW3
   jog x                         ;Turn TRIM4 to jog until limits, TRIM3 to change acceleration and TRIM5 to change velocity

                    ;A momentary logic '1' must be applied to IN1 to exit this command. A simultaneous momentary logic '1' on IN2 and
                    ;IN3 (pressing SW2 & SW3 at the same time) can also exit this command.

;Test SPEED command: Axis SPEED CONTROL +(-)N    (N is from 0 to 32767)

   x speed control +1000        ;axis X runs at a speed of 1000 CW until hitting the CW limit (IN3)
   x speed control -1000        ;axis X runs at a speed of 1000 CCW until hitting the CCW limit (IN2)
   analog inputs to x           ;prepare to use TRIM4 & TRIM5 to control the speed
   x speed control +1000        ;Use TRIM4 for CCW & TRIM5 for CW speed control

                    ;A simultaneous momentary logic '1' on IN2 and IN3 (pressing SW2 & SW3 at the same time) will exit this command.

;Test POSITION ADJUST Command: Axis POSITION ADJUST +/-N    (N is from 0 to 32767)
   home x, y                    ;return home first
   x +3000                      ;move X to position 3,000 CW
   x position adjust +/-2000    ;Turn TRIM5 to travel back and forth between position 1,000 and 5,000 (3,000 +/-2,000)

                                ;A momentary logic '1' must be applied to IN1 to exit this command.

   ;warning: user should use appropriate value of N when using this command to avoid over the limit problem

;Draw Square Five Times From Position 10,000 on both axis
```

```
   home x, y      ;return home first
   x +1000, y +1000 ;move X and y to position 1,000 CW
Lsquare:
   x +5000       ;move X axis 5,000 steps CW to draw horizontal side of the square (forward)
   y +5000       ;move Y axis 5,000 steps CW to draw vertical side of the square (forward)
   x -5000       ;move X axis 5,000 steps CCW to draw horizontal side of the square (backward)
   y -5000       ;move Y axis 5,000 steps CCW to draw vertical side of the square (backward and come back to the origin)
   goto Lsquare, loop 5 times   ;do this 5 times (draw 5 squares)

End:
   goto End

xconfig:
   x configure: 0.8 amps, idle at 76% after 2.5 seconds
   x limit cw 90000    ;set CW limit for safe
   x zero offset 1000  ;set the offset if needed
   x acceleration 32   ;set the initial acceleration
   x velocity 8000     ;set the initial velocity
   return

yconfig:
   y configure: 0.8 amps, idle at 75% after 2.5 seconds
   y limit cw 80000
   y zero offset 1000
   y acceleration 32
   y velocity 8000
   return

;EOF
```

NOTE: THIS IS JUST AN EXPLORATION OF POSSIBLE NEW COMMANDS.

MOVING AVERAGE FILTER **CONFIGURATION COMMAND**

Syntax: **MOVING AVERAGE a, a, a, a n SAMPLES <ENTER>**
Operands: **a** = axis **X** or **Y** or **Z** or **W**
0 < **n** <=127
Operation: Associates which axis are moving average filtered.
Type: The command settings are global.

Description:
1) Moving average filtering dampens the 'jerk factor' (makes the velocity 2nd derivative finite) when an axis uses ramped acceleration.
2) Rounds abrupt vector angle changes during vector motion. This rounding allows higher vector velocities and it smooths the vector path along piece-wise linear approximations of curves.

Example:

MOVING AVERAGE X, Y, 100 SAMPLES <ENTER>
MOVING AVERAGE is the MOVING AVERAGE command
X includes the X axis
, indicates another axis is to be included
Y includes the Y axis
<SP> means all included axis are listed
100 means the MOVING AVERAGE filter will use 100 samples
<ENTER> means the command is complete

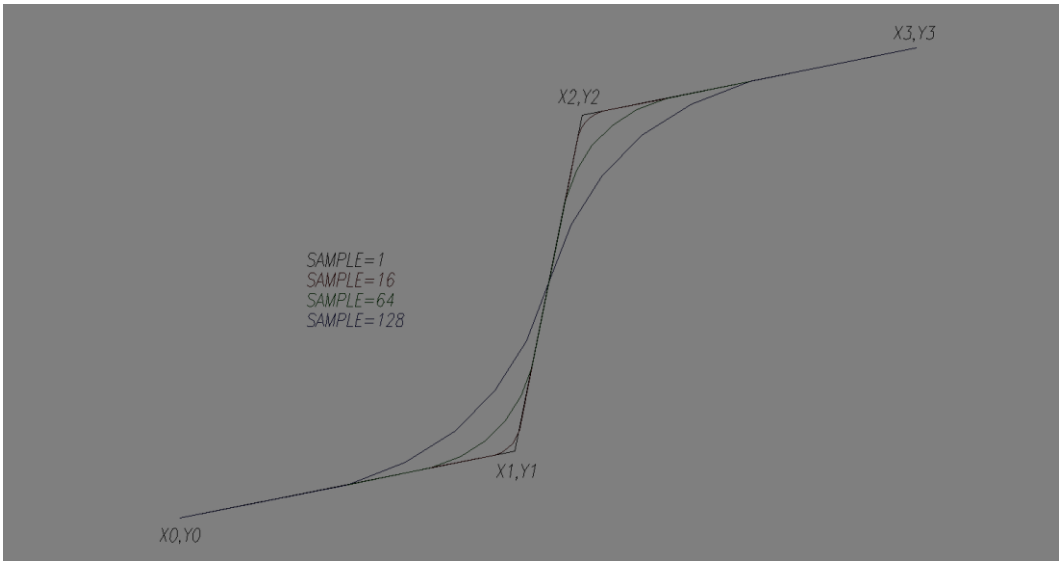
The moving average filter can be turned ON or OFF for selected axis. Using the previous example, the following turns filtering OFF for the X and Z axis:

MOVING AVERAGE Y <ENTER>

The X and Z axis have been removed from the included list. The SAMPLES value is unchanged and continues to be used for the Y axis. To turn the moving average filter back ON for the just the X and Y axis:

MOVING AVERAGE X, Y <ENTER> To turn the filter OFF for all axis: **MOVING AVERAGE <ENTER>**

The figure below shows the effect of different SAMPLE values. The black path shows the motion path has a SAMPLE value of 1 (no moving average filtering). The red path is for a SAMPLE value of 16, the green path is for a SAMPLE value of 64 and the blue path is for a SAMPLE value of 128. The vector motion path becomes progressively more rounded as the number of SAMPLE values increase.



GROUP AXIS **CONFIGURATION COMMAND**

Syntax: GROUP A IS ad ad ad a AXIS <ENTER>
Operands: **G** = GROUP command
a = axis **X** and **Y** and **Z** and **W** in that order
d = **,** or **<SP>**
Operation: Assigns axis to groups

Description:
The **GROUP** command assigns the axis to groups that have common function and each member axis in a group runs from the same user program. A different group can run a different user program. A group has 1 to 4 member drives and up to 4 groups can be active if each group has a single axis as a member.

The first group is called GROUP A and it must have the X axis as its first member. Additional members (if any) must be the Y axis, then the Z axis and then the W axis in that order. Additional groups (if any) are called GROUP B, GROUP C and GROUP D.

All axis, no matter which group they are in, know the status of all the other attached axis.

The purpose of grouping the axis allows multiple drives to perform tasks independently of other grouped axis.

EXAMPLE:

GROUP A IS X, Y AXIS, GROUP B IS Z, W AXIS <ENTER>

In this example the GROUP A user program might command the X, Y axis motors to operate an X, Y table while the GROUP B user program might command the Z, W axis motors to operate a lathe. Both programs would run independently of each other.

EXTERNAL INTERRUPT **PROGRAM FLOW COMMAND**

Syntax: EXTERNAL INTERRUPT GOTO n IF a AXIS i TURNS c <ENTER>
Operands: **a** = **X** or **Y** or **Z** or **W** axis name
i = **IN1** or **IN2** or **IN3** or **RDY** or **ERR**
c = **ON** or **OFF**
0 =< **n** < 65,536
Operation: If axis **a** input **I** condition **c** is true, go to program line **n.**

EXAMPLE:

EXTRERNAL INTERRUPT GOTO 12345 IF Z AXIS IN3 TURNS ON <ENTER>

In this example maybe the user wishes to pause the X, Y axis motion when IN3 turns on. The interrupt service code located at 12345 would have commands that see if the axis velocity value is zero. If not, the value would be made zero. If it was zero, the original velocity value would be restored. For that example IN3 would act as push-on, push-off switch pause and resume axis motion.

CHANGE SCALE **MISCELLANEOUS COMMAND**

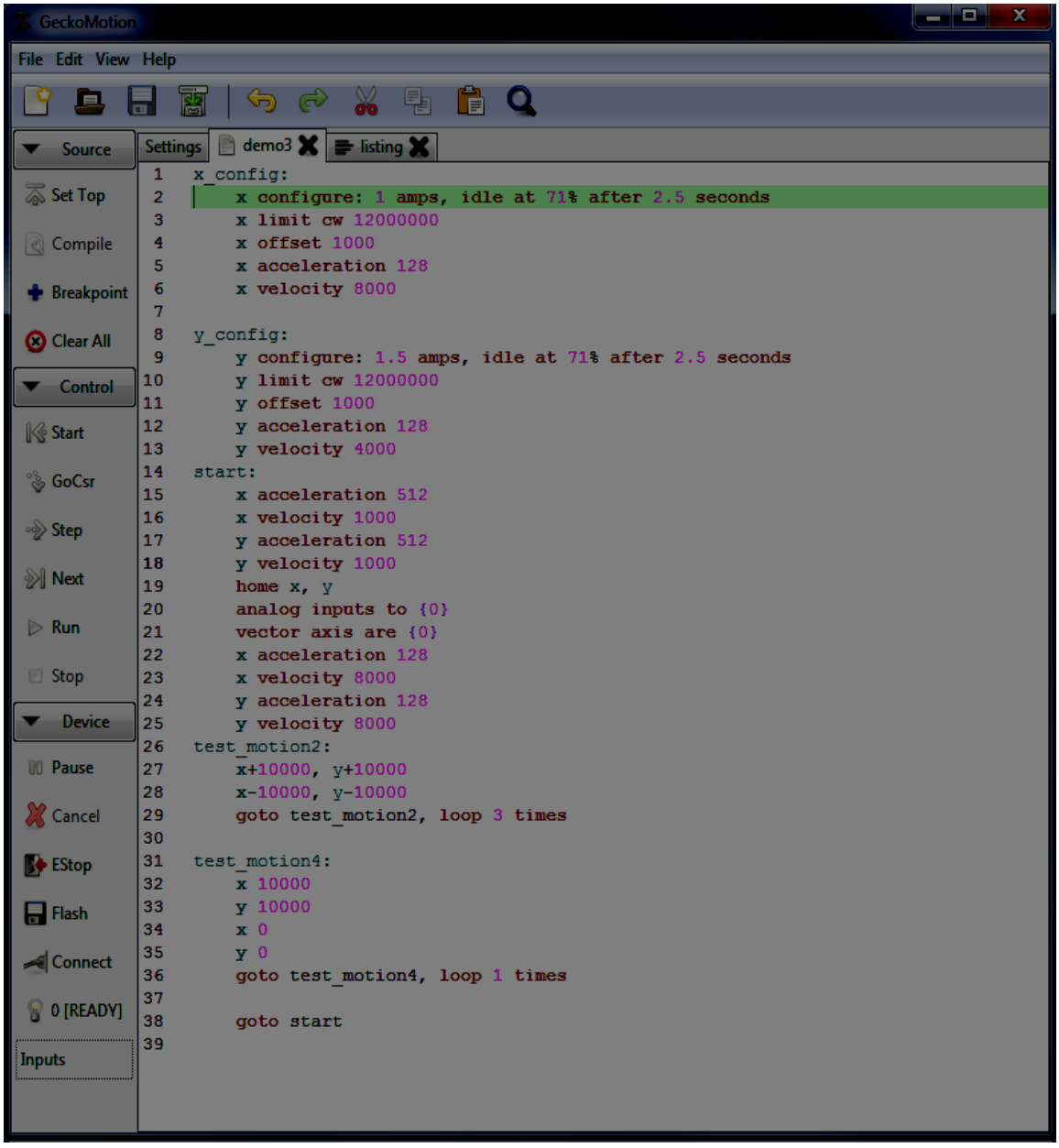
ROTATE **MISCELLANEOUS COMMAND**

ENCODER **MISCELLANEOUS COMMAND**

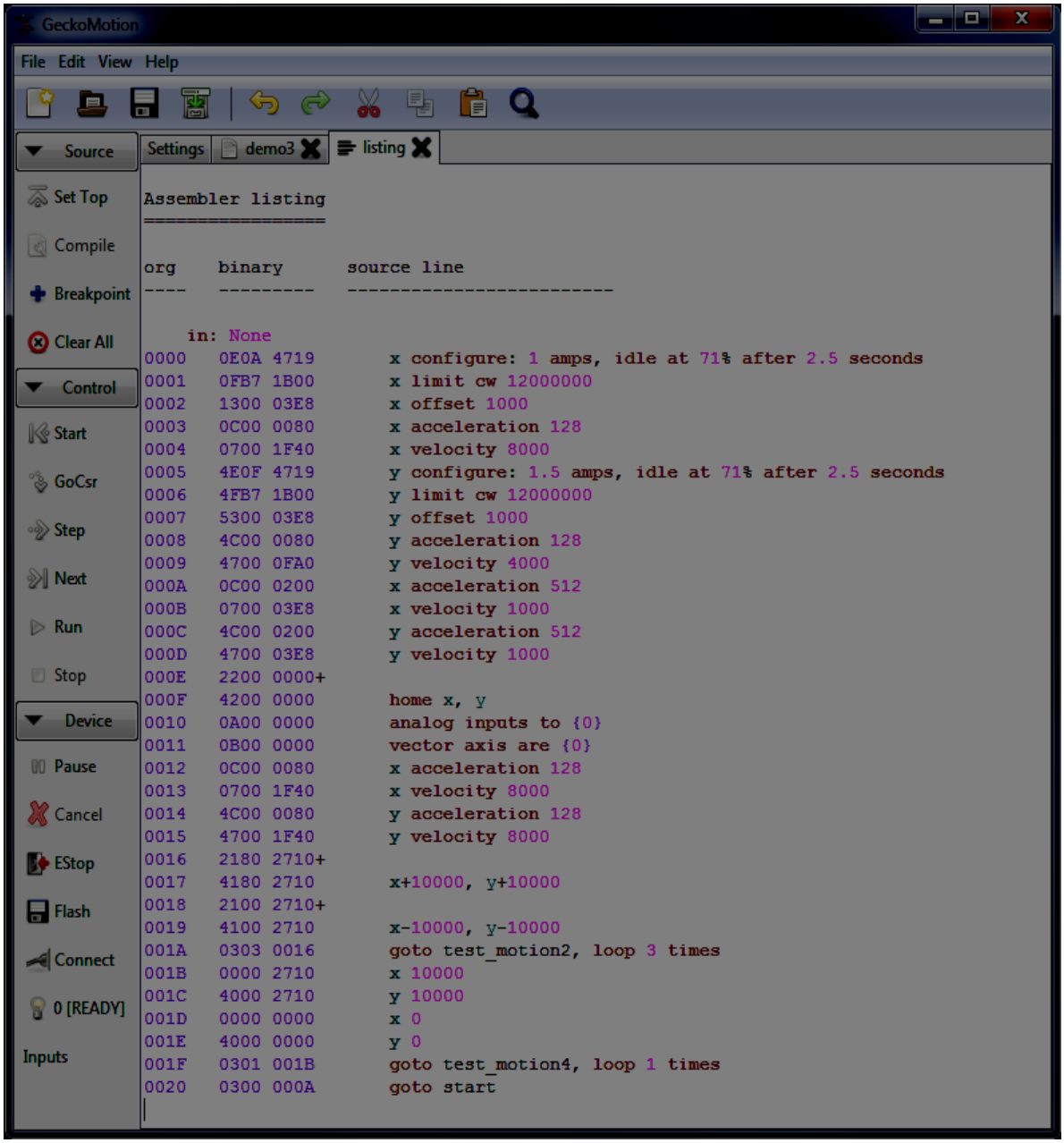
TANGENT **MOTION COMMAND**

USING THE EDIT MODE

The EDIT MODE is used to write, debug or read back the user program to and from the GM215.



"demo3" SAMPLE PROGRAM BEFORE COMPILED



“demo3” LISTING PROGRAM AFTER COMPILED

APPENDIX:

This section gives a brief description of the GM215 motion controller is organized and describes how to convert a text based command into the 2-word binary format command used by the GM215. The GM215 can have up to 32 commands in its command-set. Presently there are about 25 defined commands which leaves expansion room for additional commands in the future.

The GM215 uses a 4 chip-set to perform its motion control functions. They are:

1) A Microchip PIC24F16KL402 MCU for data processing, 4 channel ADC conversion, 2 SPI interfaces, UART and bootloader
2) An Actel ProAsic3 A3P030 FPGA for motor drive logic, step frequency generator, timebase, interrupt generator and I/O
3) A 25PE20 SPI interface 2MB flash memory for non-volatile user program storage
4) A 3072 RS-485 transceiver

The GM215 can operate as a standard STEP/DIRECTION input microstep motor drive or as a motion-control enabled microstep motor drive. The motion controller has 2 modes of operation; EDIT MODE or RUN MODE. The EDIT mode requires PC USB connection to an RS-485 'Smart Cable' and GeckoMotion.exe GUI running on the PC.

RUN MODE:

In the RUN MODE the drives read commands from non-volatile flash memory and execute the commands without a PC connection. The RS-485 connection must be used when two or more drives are expected to coordinate their activity. It isn't necessary if only a single drive is used or if multiple drives have completely independent tasks.

MASTER AND SLAVE DRIVE DESIGNATION:
The GM215 is designed to operate as multiple-axis motion controller when two or more drives (maximum of 4 drives) are connected via the RS-485 interface. Each drive reserves two DIP switch settings (SW3 and SW4) to set the drive's axis name (X, Y, Z or W) and one drive must be named 'X' designating it as the MASTER axis while the other drives are set as SLAVE axis (Y, Z or W).

PHASE-LOCK SLAVES TO MASTER:
The MASTER drive's controller runs from its crystal controlled oscillator while the SLAVE drives run from their tunable (+/- 2%) oscillators. The MASTER drive transmits a SYNC pulse over the RS-485 interface which is used by the SLAVE drives to phase-lock their clock oscillators to the MASTER drive's crystal controlled oscillator frequency. This insures all SLAVE drives synchronize themselves to the MASTER drive's clock and execute the user's application program exactly at the same place and time as the MASTER drive.

ALL DRIVES USE THE SAME USER PROGRAM:
The flash memories of all drives are programmed identically. Many commands such as MOVE has coordinates that apply only to a specific drive. The drive named X will only process the X coordinates for its motor while the Y drive will only process the Y coordinates and a Z drive will ignore X, Y coordinates for its motor altogether. All drives process the data for the commanded axis motions but only output to the motors the data that matches their name. Other commands such as WAIT are global and apply to all axis. All drives process this command simultaneously and all finish at the same time.

The advantage is the same program can be flashed to all the drives simultaneously which saves time, only a single program has to be written, debugged and maintained and the drives become interchangeable by just renaming them.

ALL DRIVES PASS INFORMATION TO EACH OTHER:
Some commands like HOME for multiple axis can take an undetermined amount of time to finish and the next command cannot start until all drives finish the HOME routine. Each connected drive in turn transmits its STATUS to all the other drives, in this case it's each drive's BUSY/READY status. The BUSY/READY status indicates if a drive is executing a command or if the command is finished. When all drives transmit a READY then the next command can be executed.

Each drive has 3 opto-isolated inputs and 3 opto-isolated outputs. Normally switches are connected to the inputs and all drives need to know the state of its own inputs and the inputs of all the connected drives. This is because the IF-THEN-ELSE command may be used to change the program flow based on inputs. All drives have to make the same program flow decision. The transmitted STATUS from each drive provides this information. Finally, the STATUS also informs all drives of an ERROR condition in any drive.

THE USER PROGRAM MUST LOOP-BACK ON ITSELF:
The GM215 drive or drives are attached to a mechanism that is driven by a motor or motors. In most cases the mechanism performs a repetitive sequence of events that has a beginning and an end. At the end of this sequence the user program must loop back to the beginning to repeat the cycle. This may an IF-THEN-ELSE command that polls a 'start' switch connected a drive's input.

EDIT MODE:

The EDIT MODE is used for:

1) Writing, testing and debugging a user program
2) Programming the flash memory with the user program
3) Loading GM215 firmware updates.

In the EDIT mode all drives switch to their crystal oscillators and the host PC UART becomes the master. As master, only the host can initiate transmissions over the RS-485 bus. The host can query the drives and the queried drive will reply with an 8-byte data block containing current information about the drive. The default UART settings are 115,000 Baud, 8-bit date, no parity, 1 stop bit.

The host PC communicates with the drives using SPECIAL COMMANDS in the EDIT mode. These are distinct from the user program commands used in the RUN mode. These are:

0) E_STOP	0x0000	Stops command execution immediately
1) STOP	0x0001	Stops when current command is finished
2) PAUSE	0x0002	Decelerates all axis to a stop
3) RESUME	0x0003	Resumes a command from PAUSE
4) RUN	0x0004	Execute the specified command line and stop
5) PROGRAM_FLASH_ROM	0x0005	Flash the entire memory from a file
6) UPDATE_FIRMWARE	0x0006	Allows updating the PIC firmware from a file
7) QUERY_SHORT	0x0007	Returns all attached axis status and X axis program counter only
8) QUERY_LONG	0x0008	Returns all attached axis full information.
9) LOAD_PGM_COUNTER	0x0009	Loads the drive's program counter with a base value
A) TBD	0x000A	To be determined
B) READ_BACK	0x000B	Read back from flash memory
C) BULK_ERASE	0x000C	Erase the whole flash memory
D) TEST_IN	0x000D	Software simulate input

E_STOP and **STOP** **EDIT MODE COMMAND**

Syntax: 0x0000 for E_STOP
0x0001 for STOP

Description:
The E_STOP command will immediately shut-off the motors without deceleration and turn-off the motor current. Send: 0x0000
The STOP command will terminate user command execution after the current command finishes. Send: 0x0001

PAUSE **EDIT MODE COMMAND**

Syntax: 0x0002 for PAUSE

Description: Immediately decelerates all attached axis to a stop at their programmed rates of acceleration. This command can be sent at any time, even when axis are in motion moving towards their programmed destination coordinates.

RESUME **EDIT MODE COMMAND**

Syntax: 0x0003 for RESUME

Description: RESUME accelerates all attached axis to their previous velocities at their programmed rates of acceleration. This command can be sent at any time, all axis will resume moving towards their original destinations.

RUN **EDIT MODE COMMAND**

Syntax: 0x0004 for RUN followed by USER COMMAND

Description:
RUN_COMMAND_LINE will execute a single user command sent from the host GUI and then stop. All attached drives read the sent command, if the command names drives then only those drives will execute the command and the unnamed drives will ignore it. The sent user command is not stored to the attached GM215 flash memories.

The ADDRESS is used by the guest axis to calculate the next user command address. If executing the user command doesn't change program flow then the calculated address will be the host-sent ADDRESS + 1. Program flow user commands use the host-sent ADDRESS to calculate relative next user command addresses; absolute addresses decode directly from the sent user command and don't use the host-sent ADDRESS.

All attached drives need to know all other drives' status to properly execute program flow commands. The Busy/Ready flags of all the involved drives indicate Ready when user command is completed.

Example 1:
A possible host RUN command line is **IF Z IN 2 OFF GOTO <label>**. To execute this command line (assume label = 614), send:

0x0004	The host UART sends 0x04, 0x00	This is the special command RUN
0x0266	The host UART sends 0x66, 0x02	This is the lower word for the user command in hex.
0x85A2	The host UART sends 0xA2, 0x85	This is the upper word for the user command in hex.

The guest axis sends a SHORT_QUERY reply to the host:

X STATUS low byte, then X STATUS high byte,
X PC ADDRESS low byte, then X PC ADDRESS high byte,
Y STATUS low byte, then Y STATUS high byte,
Z STATUS low byte, then Z STATUS high byte,
W STATUS low byte, then W STATUS high byte,

See the SHORT_QUERY reply format on page 40.

The host needs to reply when a sent user command is completed. The sequence is:

1) Host waits until it receives the entire reply.
2) Host sends a SORT_QUERY or LONG_QUERY command. Guests reply accordingly.
3) Host waits until it receives the entire reply.
4) Host inspects message for 'Ready' on all involved guest axis.
5) If all aren't 'Ready', host goes to step (2).
6) All are 'Ready'. The reply PC ADDRESS is the next user command address.

Example 2:
The host wishes to RUN a user command **X+4000, Y-3000, W 5000** . The host sends:

0x0004		RUN command
0x0FA0	0x2180	User command **X+4000,**
0x0BB8	0x6100	User command **Y-3000,**
0x1388	0xC000	User command **W 5000**

PROGRAM_FLASH_ROM **EDIT MODE COMMAND**

Syntax: 0x0005 for PROGRAM_FLASH_ROM

Description: After successfully compiled, user can download the program to the BIG ROM on board. The PC should send 0x0005 first and then start to send the data stream. Contact Geckodrive for more details.

UPDATE_FIRMWARE **EDIT MODE COMMAND**

Syntax: 0x0006 for UPDATE_FIRMWARE

Description: Contact Geckodrive for more details.

QUERY_SHORT **EDIT MODE COMMAND**
QUERY_LONG **EDIT MODE COMMAND**

Syntax: 0x0007 for QUERY_SHORT
0x0008 for QUERY_LONG

Description:
The QUERY_LONG command updates each axis' inputs, outputs, position, velocity, errors and Busy/Ready status. This can be used as a near real-time update if the host sends the LONG_QUERY command repeatedly. Each axis will immediately reply with a 10-byte block of data for each axis. The order of reply will be X, Y, Z and W, each 10 bytes long. If an axis is not attached or malfunctioning, it will be skipped. It is important to wait for the axis to reply before issuing another command, otherwise Tx collisions may result. The LONG_QUERY reply takes 3.48 milliseconds. The reply format is:

Byte 1: Drive status byte 1. Busy/Ready flag, input states, Error flag and axis name.
Byte 2: Drive status byte 2. Output states, group number.
Byte 3: LSB of the axis program counter (PC [7:0]).
Byte 4: MSB of the axis program counter (PC [15:8]).
Byte 5: Real time motor position register (MP [7:0]).
Byte 6: LSB of the motor position register (POS [7:0]).
Byte 7: Middle byte of the motor position register (POS [15:8]).
Byte 8: MSB of the motor position register (POS [23:16]).
Byte 9: LSB of the axis velocity (VEL [7:0]).
Byte 10: MSB of the axis velocity (VEL[15:8]).

Byte 1, 11, 21, 31	Byte 2, 12, 22, 32	Byte 3, 13, 23, 33	Byte 4, 14, 24, 34	Byte 5, 15, 25, 35
bit 7 = IN1	bit 7 = TBD	bit 7 = PC [7]	bit 7 = PC [15]	bit 7 = MP [7]
bit 6 = IN2	bit 6 = OUT3	bit 6 = PC [6]	bit 6 = PC [14]	bit 6 = MP [6]
bit 5 = IN3	bit 5 = OUT2	bit 5 = PC [5]	bit 5 = PC [13]	bit 5 = MP [5]
bit 4 = ERR1	bit 4 = OUT1	bit 4 = PC [4]	bit 4 = PC [12]	bit 4 = MP [4]
bit 3 = ERR2	bit 3 = TBD	bit 3 = PC [3]	bit 3 = PC [11]	bit 3 = MP [3]
bit 2 = BSY/RDY	bit 2 = TBD	bit 2 = PC [2]	bit 2 = PC [10]	bit 2 = MP [2]
bit 1 = AXIS1	bit 1 = GP1	bit 1 = PC [1]	bit 1 = PC [9]	bit 1 = MP [1]
bit 0 = AXIS0	bit 0 = GP0	bit 0 = PC [0]	bit 0 = PC [8]	bit 0 = MP [0]

Byte 6, 16, 26, 36	Byte 7, 17, 27, 37	Byte 8, 18, 28, 38	Byte 9, 19, 29, 39	Byte 10, 20, 30, 40
bit 7 = POS [7]	bit 7 = POS[15]	bit 7 = POS[23]	bit 7 = VEL[7]	bit 7 = VEL[15]
bit 6 = POS [6]	bit 6 = POS[14]	bit 6 = POS[22]	bit 6 = VEL[6]	bit 6 = VEL[14]
bit 5 = POS [5]	bit 5 = POS[13]	bit 5 = POS[21]	bit 5 = VEL[5]	bit 5 = VEL[13]
bit 4 = POS [4]	bit 4 = POS[12]	bit 4 = POS[20]	bit 4 = VEL[4]	bit 4 = VEL[12]
bit 3 = POS [3]	bit 3 = POS[11]	bit 3 = POS[19]	bit 3 = VEL[3]	bit 3 = VEL[11]
bit 2 = POS [2]	bit 2 = POS[10]	bit 2 = POS[18]	bit 2 = VEL[2]	bit 2 = VEL[10]
bit 1 = POS [1]	bit 1 = POS[9]	bit 1 = POS[17]	bit 1 = VEL[1]	bit 1 = VEL[9]
bit 0 = POS [0]	bit 0 = POS[8]	bit 0 = POS[16]	bit 0 = VEL[0]	bit 0 = VEL[8]

The QUERY_SHORT command requests the X axis to reply with two STATUS bytes and its two PC ADDRESS bytes. All the other attached axis to reply with just their two STATUS bytes each. The order of reply will be X, Y, Z and W. If an axis is not attached or malfunctioning, it reply time slot is empty. The QUERY_SHORT reply takes 0.87 milliseconds. The reply format is:

Byte 1=X, 5=Y, 7=Z, 9=W	Byte 2=X, 6=Y, 8=Z, 10=W	Byte 3=X	Byte 4=X
AXIS STATUS1 byte	AXIS STATUS2 byte	PC ADDRESS LOW byte	PC ADDRESS HIGH byte
bit 7 = IN1	bit 7 = TBD	bit 7 = PC [7]	bit 7 = PC [15]
bit 6 = IN2	bit 6 = OUT3	bit 6 = PC [6]	bit 6 = PC [14]
bit 5 = IN3	bit 5 = OUT2	bit 5 = PC [5]	bit 5 = PC [13]
bit 4 = ERR1	bit 4 = OUT1	bit 4 = PC [4]	bit 4 = PC [12]
bit 3 = ERR2	bit 3 = TBD	bit 3 = PC [3]	bit 3 = PC [11]
bit 2 = BSY/RDY	bit 2 = TBD	bit 2 = PC [2]	bit 2 = PC [10]
bit 1 = AXIS1	bit 1 = GP1	bit 1 = PC [1]	bit 1 = PC [9]
bit 0 = AXIS0	bit 0 = GP0	bit 0 = PC [0]	bit 0 = PC [8]

LOAD_PROGRAM_COUNTER **EDIT MODE COMMAND**

Syntax: 0x0009 for LOAD_PROGRAM_COUNTER followed by PROGRAM COUNTER VALUE

Description:
The LOAD_PROGRAM_COUNTER command initializes the GM215 program counter to a value sent by the host. This allows the host to start running the user program from any address location inside the user program instead of only from the beginning. This facilitates debugging the user program by not having to run time-consuming commands that lead up to the command that requires debugging.

This command is used in conjunction with the RUN special command. The host sends this special command followed by a 2-byte program counter value, that being the address of the subsequent RUN command. The LOAD_PROGRAM_COUNTER command is only needed when the host intends to send an out of sequence RUN command.

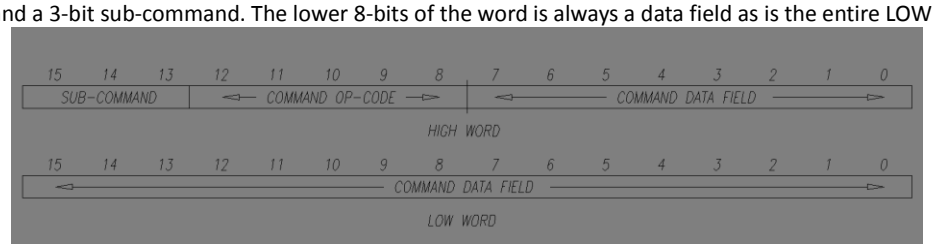
Example:
The host wishes to RUN an out of sequence user command **X+4000, Y-3000, W 5000** . The host sends:

0x0009		LOAD_PROGRAM_COUNTER command
0xA93C		Program address for the following user command
0x0004		RUN command
0x0FA0	0x2180	User command **X+4000,**
0x0BB8	0x6100	User command **Y-3000,**
0x1388	0xC000	User command W **5000**

When this motion command finishes execution, the X axis GM215 updates its program counter to the next user program address, in this case its 0xA93D. The next QUERY shows this update and the host uses this address to fetch the next user command.

The rest of this section describes how the user commands are converted from text to binary machine language format.

COMMAND FORMAT:
2 words are used to form a command, here called HIGH WORD and LOW WORD. The upper byte of the HIGH WORD contains a 5-bit command op-code and a 3-bit sub-command. The lower 8-bits of the word is always a data field as is the entire LOW WORD.

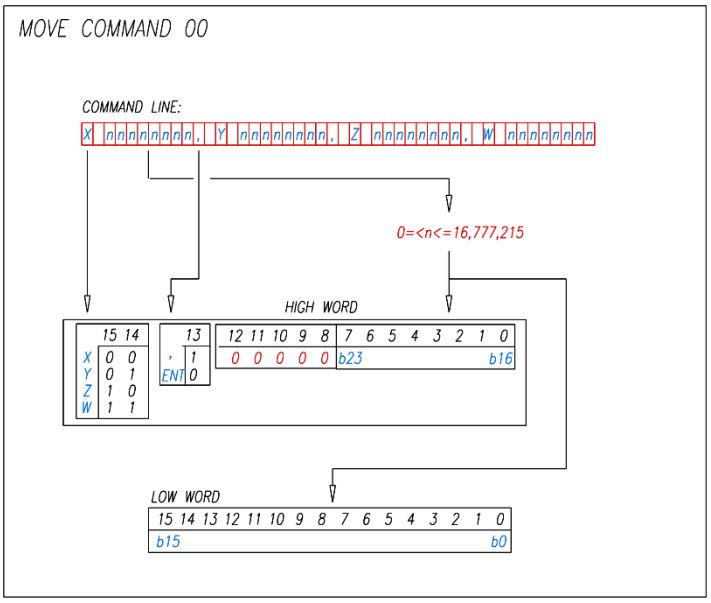


The G215 serial flash memory is byte oriented so 1 command is equal to 4 bytes of memory. Little-endian format is used meaning the least significant byte is located at the lowest address and the most significant byte is located at the highest address. This 4-byte block constitutes a single command and the program counter increments on each 4-byte read from memory.

Some commands like MOVE can be concatenated on the same command line and up to 4 axis are supported. This means up to 16 bytes are read from memory for the command line. The command line counter must be incremented 2, 3 or 4 times for 2, 3 or 4 concatenated axis respectively to show the address of the next command. Presently the flash memory supports a maximum of 65,536 command lines. This can be expanded to 524,288 lines if a larger memory is used should the need arise.

Almost any standard format such as g-code or gerber can be a source text file if the user wishes to write a text to binary converter. In the following command translation descriptions GeckoMotion text is used as the source.

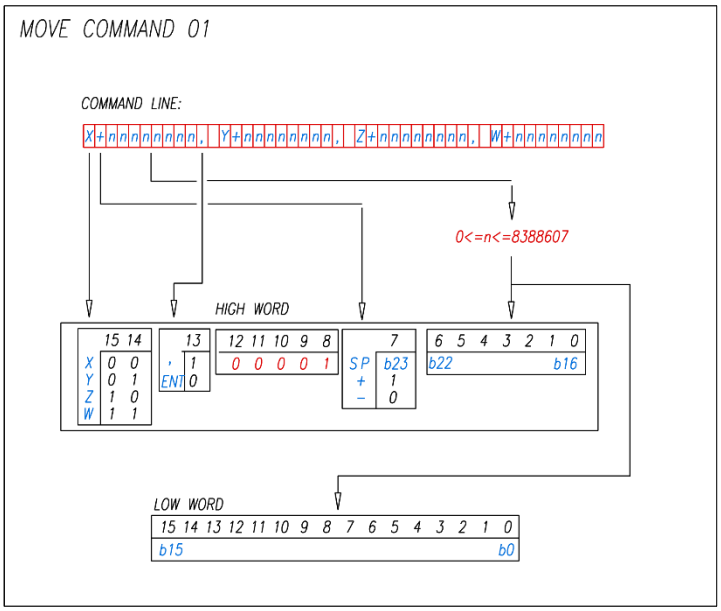
MOVE op-code 0x00 **MOTION COMMAND**



EXAMPLE:

X 255 <ENTER> **H=0000, L=00FF** **(hex value)**
Y 65535 <ENTER> **H=4000, L=FFFF**
Z 16777215 <ENTER> **H=80FF, L=FFFF**
X 15, Y 255, Z 4095, W 65535 <ENTER> **H=2000, L=000F (X COORDINATE)**
H=6000, L=00FF (Y COORDINATE)
H=A000, L=0FFF (Z COORDINATE)
H=C000, L=FFFF (W COORDINATE)

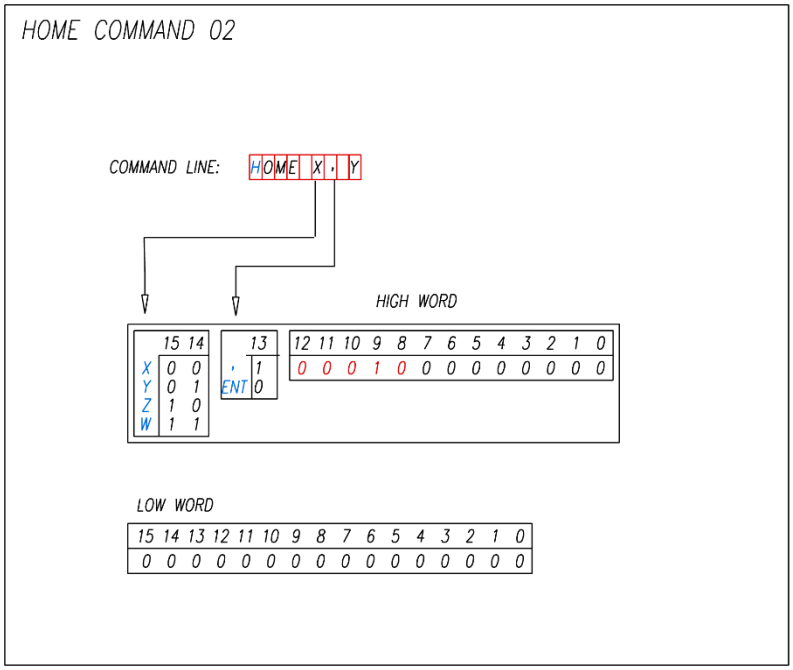
MOVE op-code 0x01 **MOTION COMMAND**



EXAMPLE:

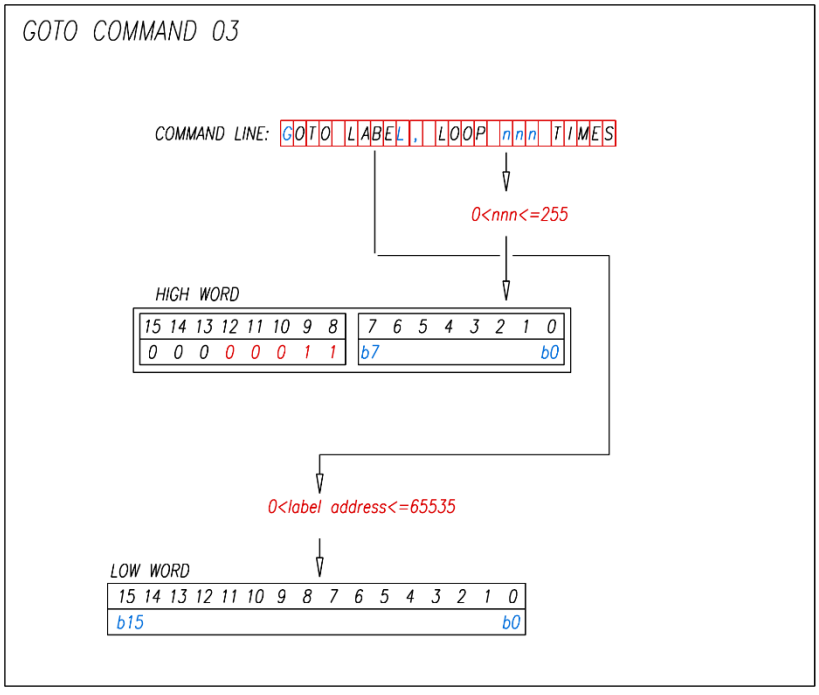
X +255 <ENTER> **H=0180, L=00FF**
Y -65535 <ENTER> **H=4100, L=FFFF**
Z +8388607 <ENTER> **H=80FF, L=FFFF**
X +15, Y -255, Z +4095, W -65535 <ENTER> **H=2180, L=000F (X COORDINATE)**
H=6100, L=00FF (Y COORDINATE)
H=A180, L=0FFF (Z COORDINATE)
H=C100, L=FFFF (W COORDINATE)

HOME op-code 0x02 **MOTION COMMAND**



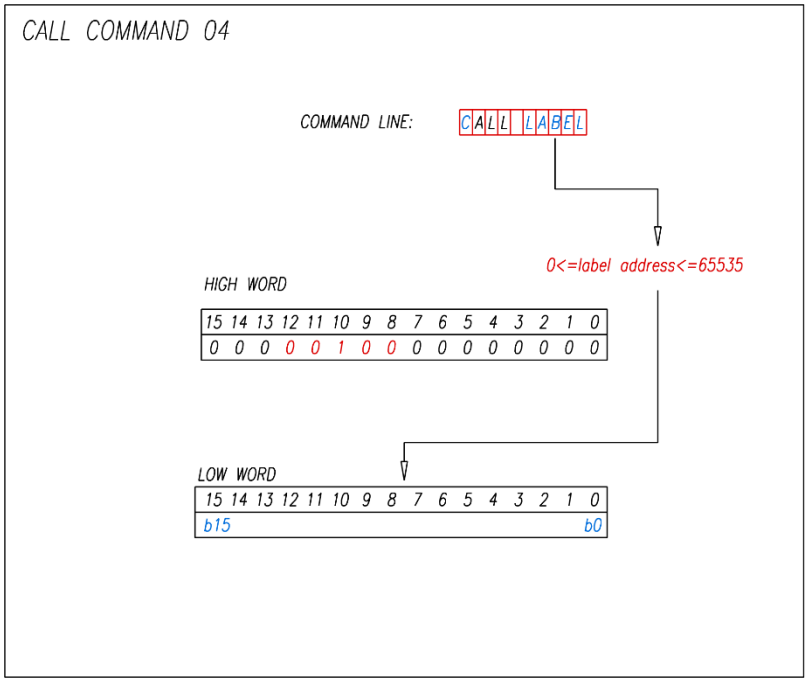
EXAMPLE: **HOME X <ENTER>** **H=0200, L=0000**
HOME X, Y, Z, W <ENTER> **H=2200, L=0000** **(X COORDINATE)**
H=6200, L=0000 **(Y COORDINATE)**
H=A200, L=0000 **(Z COORDINATE)**
H=C200, L=0000 **(W COORDINATE)**

GOTO op-code 0x03 **PROGRAM FLOW COMMAND**



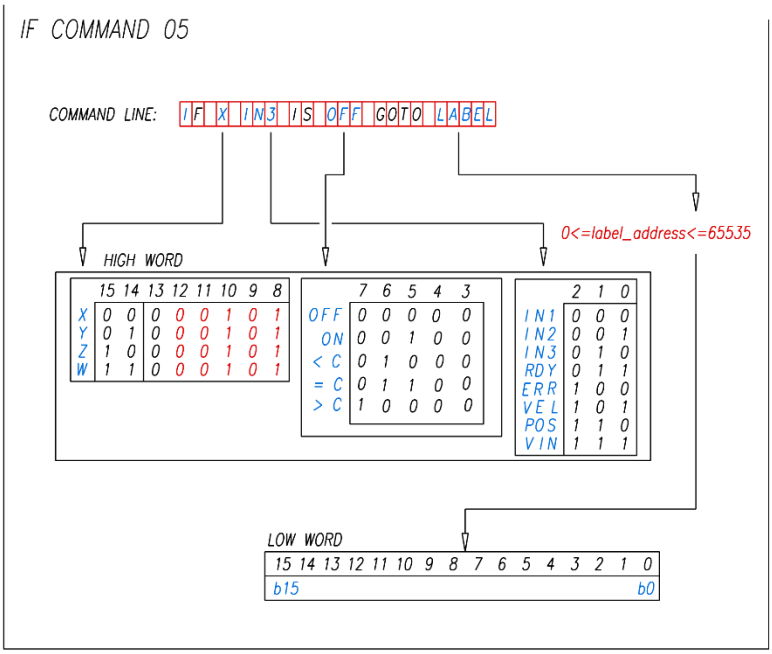
EXAMPLE: **GOTO CW_MOTION, LOOP 8 TIMES <ENTER>** **H=0308, L=000D** **(if CW_MOTION address is at 000D)**

CALL op-code 0x04 **PROGRAM FLOW COMMAND**



EXAMPLE: **CALL X_CONFIG <ENTER>** **H=0400, L=000C (if X_CONFIG address is at 000C)**

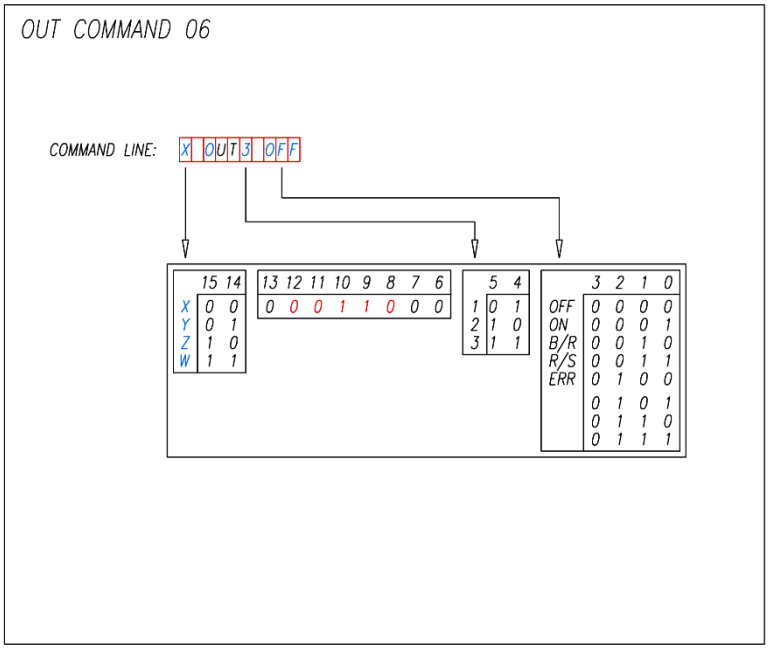
IF-THEN-ELSE **op-code 0x05** **PROGRAM FLOW COMMAND**



EXAMPLE:

IF X IN1 IS ON GOTO LOOP1 <ENTER>	**H=0520, L=000D (if LOOP1 address is at 000D)**
IF Y RDY IS OFF GOTO LOOP1 <ENTER>	**H=4503, L=000D**
IF Z ERR IS ON GOTO LOOP1 <ENTER>	**H=8524, L=000D**
IF W VEL IS < GOTO LOOP1 <ENTER>	**H=C545, L=000D**
IF X POS IS = GOTO LOOP1 <ENTER>	**H=0566, L=000D**
IF X VIN IS > GOTO LOOP1 <ENTER>	**H=0587, L=000D**

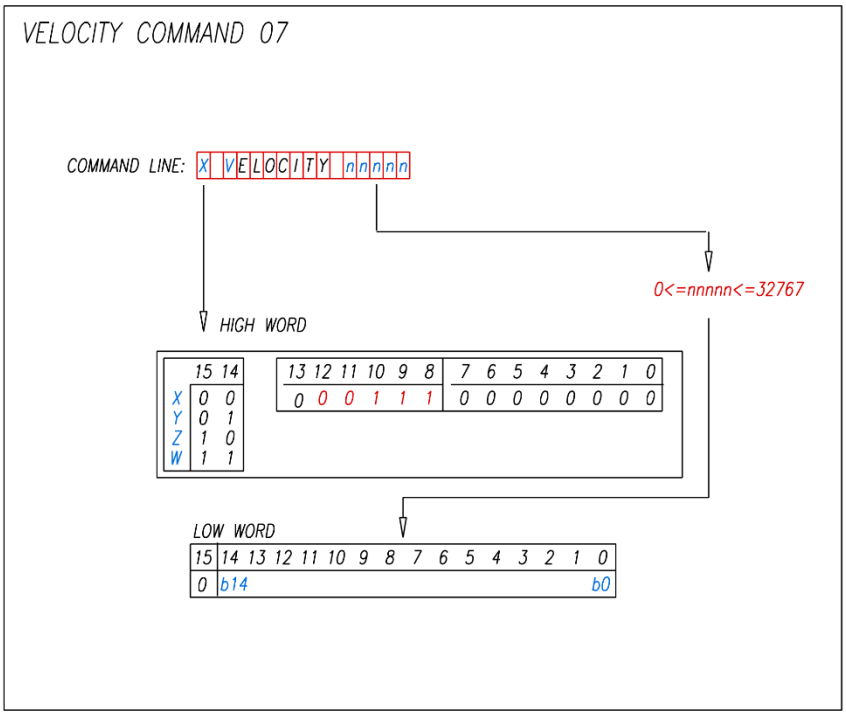
OUTPUT op-code 0x06 **MISCELLANEOUS COMMAND**



EXAMPLE:

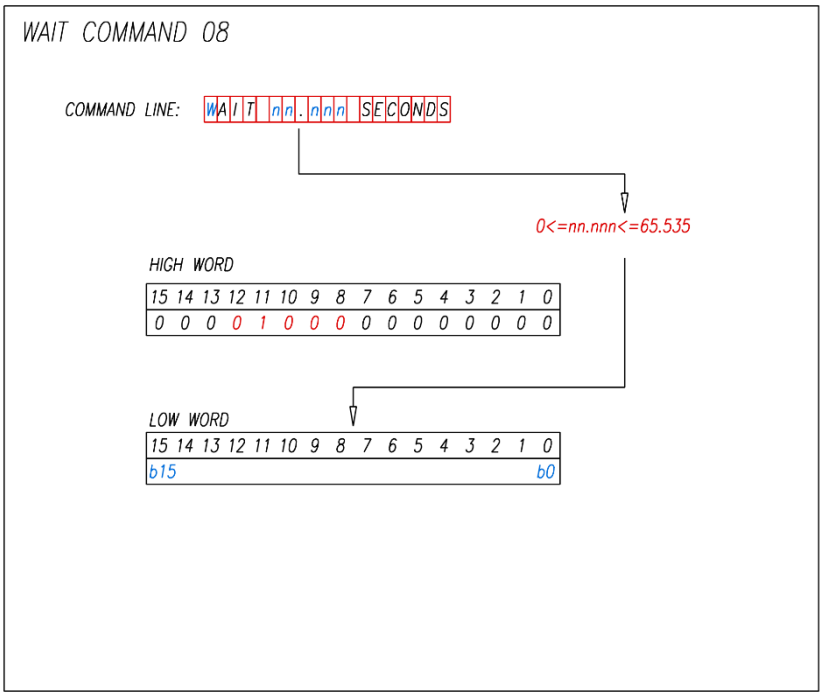
X OUT 1 ON <ENTER>	**H=0611, L=0000**
Y OUT 2 BR <ENTER>	**H=4622, L=0000**
Z OUT 3 RS <ENTER>	**H=8633, L=0000**
W OUT 1 ER <ENTER>	**H=C614, L=0000**

VELOCITY op-code 0x07 **CONFIGURATION COMMAND**



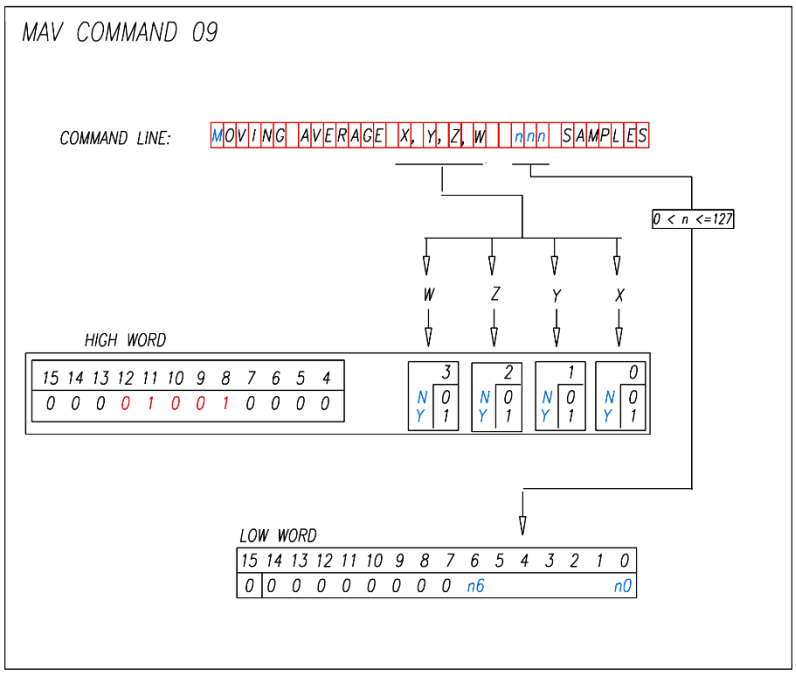
EXAMPLE: **X VEL 255 <ENTER> OR X VELOCITY 255 <ENTER>** **H=0700, L= 00FF**
Y VEL 32767 <ENTER> OR X VELOCITY 255 <ENTER> **H=4700, L= 7FFF**

WAIT op-code 0x08 **PROGRAM FLOW COMMAND**



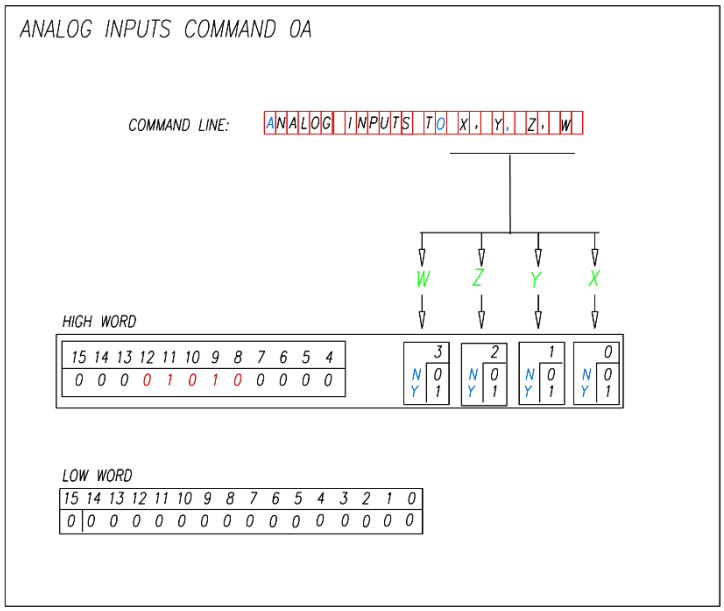
EXAMPLE: **WAIT 0.255 SECONDS <ENTER>** **H=0800, L=00FF**
WAIT 1.234 SECONDS <ENTER> **H=0800, L=04D2**
WAIT 65.535 SECONDS <ENTER> **H=0800, L=FFFF**

MOVING AVERAGE FILTER op-code 0x09 **CONFIGURATION COMMAND**



EXAMPLE: **MOVING AVERAGE X, Y, Z 100 SAMPLES <ENTER>** **H=090E, L=0064**

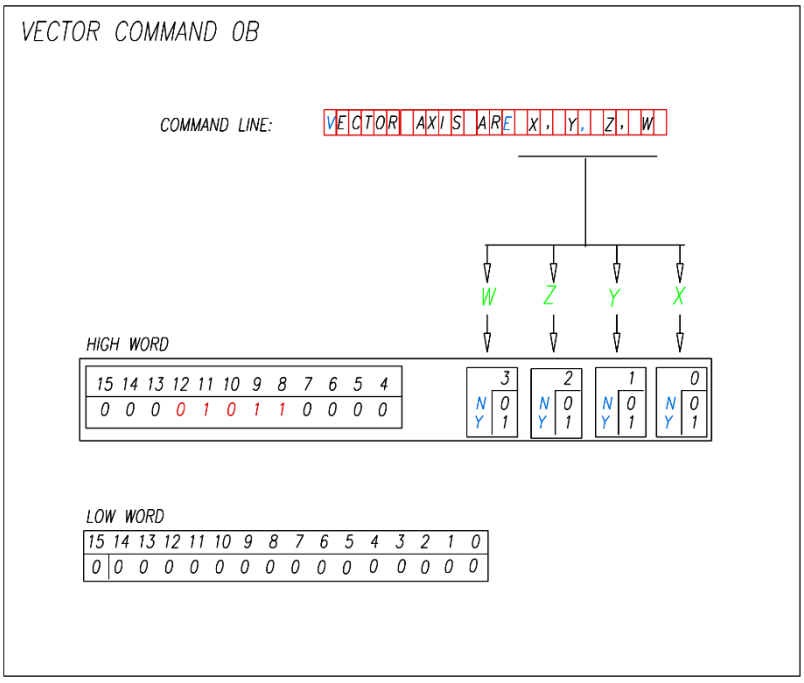
ANALOG INPUTS op-code 0x0A **CONFIGURATION COMMAND**



EXAMPLE:

ANALOG INPUT X <ENTER> **H=0A01, L=0000**
ANALOG INPUT X,Y <ENTER> **H=0A03, L=0000**
ANALOG INPUT X,Y,Z,W <ENTER> **H=0A0F, L=0000**

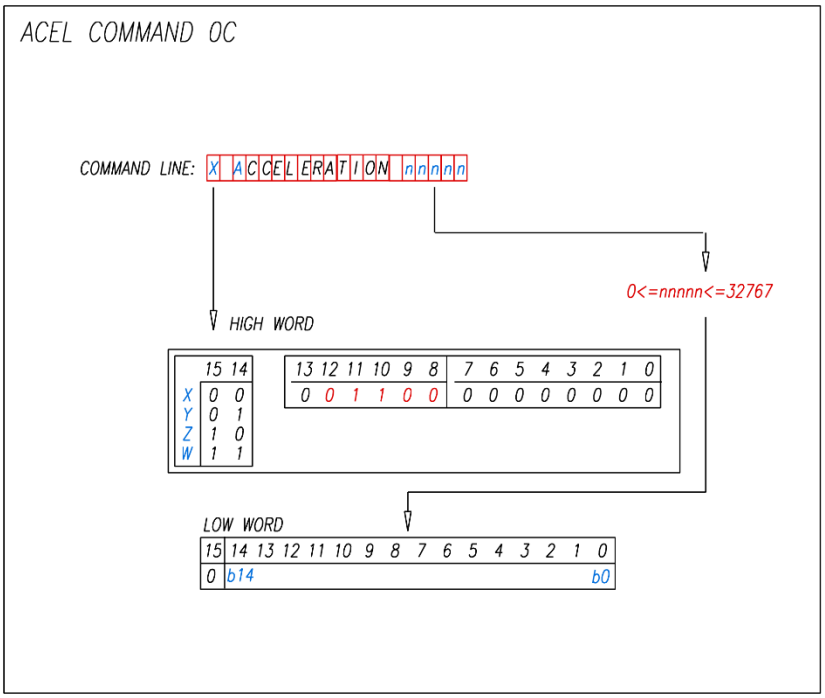
VECTOR AXIS op-code 0x0B **CONFIGURATION COMMAND**



EXAMPLE:

VECTOR AXIS ARE X <ENTER> **H=0B01, L=0000**
VECTOR AXIS ARE X, Y <ENTER> **H=0B03, L=0000**
VECTOR AXIS ARE X, Y, Z, W <ENTER> **H=0B0F, L=0000**

ACCELERATION **op-code 0x0C** **CONFIGURATION COMMAND**

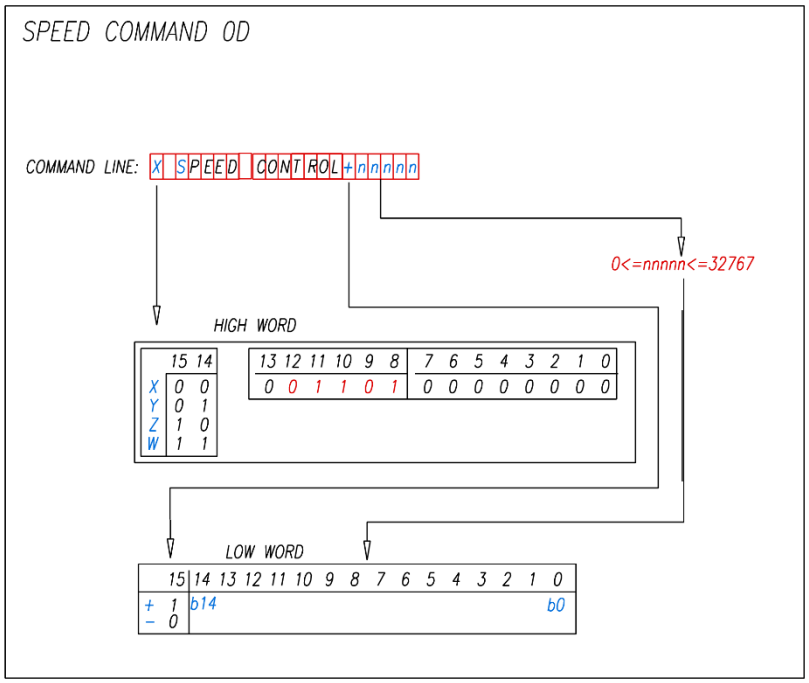


EXAMPLE:

X ACCELERATION 255 <ENTER> **H=0C00, L=00FF**

Y ACCELERATION 32767 <ENTER> **H=4C00, L=7FFF**

SPEED CONTROL **op-code 0x0D** **MOTION COMMAND**



EXAMPLE:

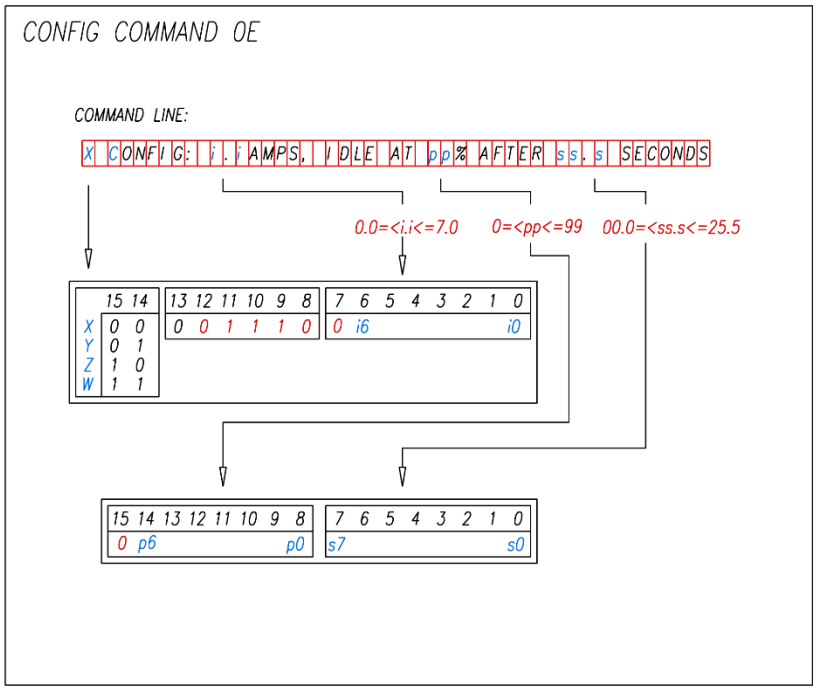
X SPEED CONTROL 15 <ENTER> **H=0D00, L=000F**

Y SPEED CONTROL +255 <ENTER> **H=4D00, L=00FF**

Z SPEED CONTROL +32767 <ENTER> **H=8D00, L=FFFF**

W SPEED CONTROL -32767 <ENTER> **H=CD00, L=7FFF**

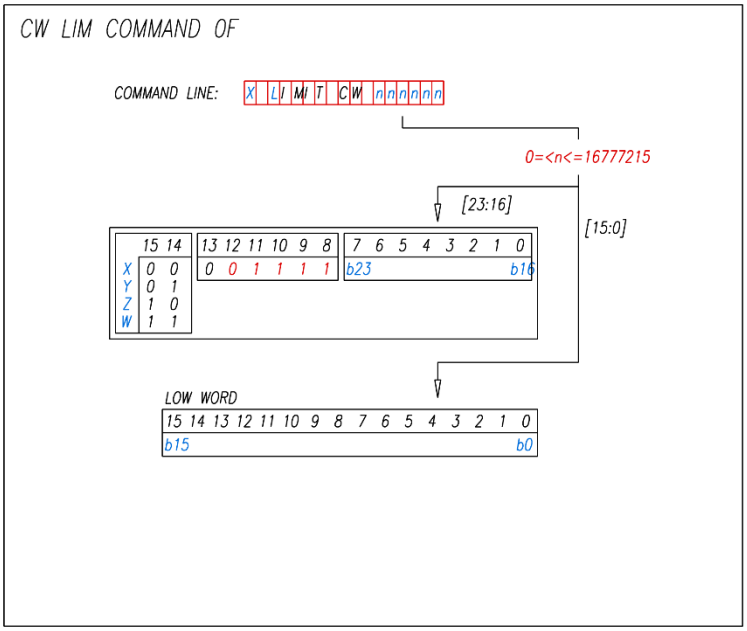
CONFIGURE AXIS op-code 0x0E **CONFIGURATION COMMAND**



EXAMPLE:

X CONFIG: 0.1 AMPS, IDLE AT 0% AFTER 0.0 SECONDS <ENTER> **H=0E01, L=0000**
Y CONFIG: 1.5 AMPS, IDLE AT 15% AFTER 1.5 SECONDS <ENTER> **H=4E0F, L=0F0F**
Z CONFIG: 7.0 AMPS, IDLE AT 99% AFTER 25.5 SECONDS <ENTER> **H=8E46, L=63FF**

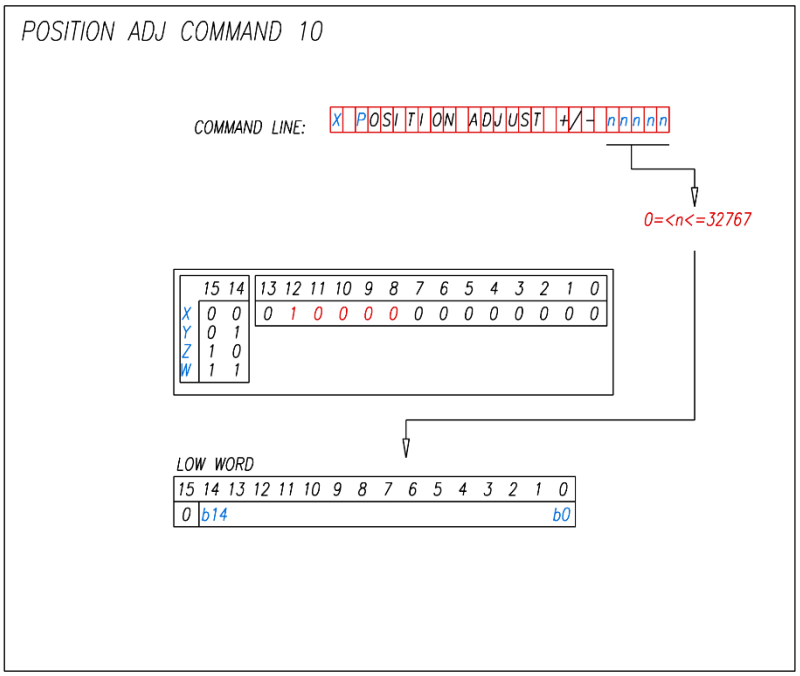
LIMIT CW op-code 0x0F **CONFIGURATION COMMAND**



EXAMPLE:

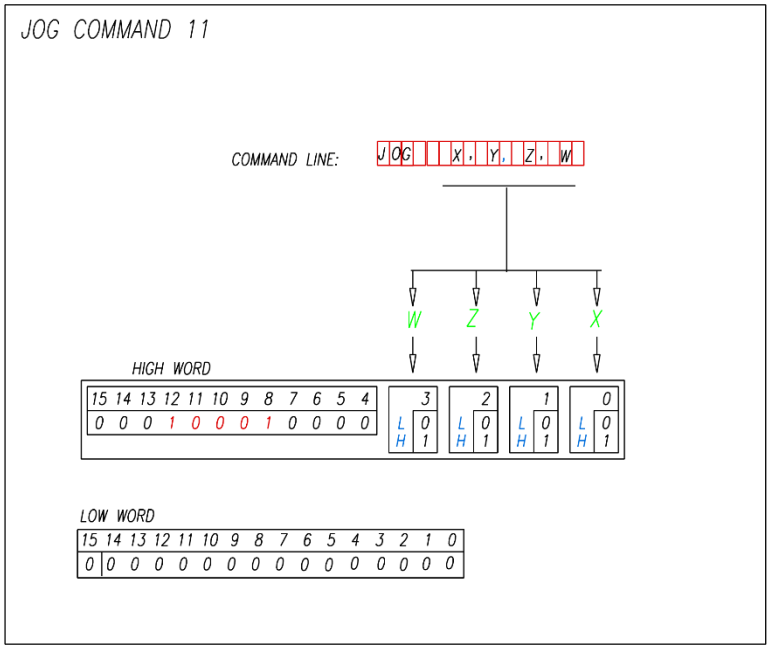
X LIMIT CW 255 <ENTER> **H=0F00, L=00FF**
Y LIMIT CW 65535 <ENTER> **H=4F00, L=FFFF**
Z LIMIT CW 16777215 <ENTER> **H=8FFF, L=FFFF**

POSITION ADJUST op-code 0x10 **CONFIGURATION COMMAND**



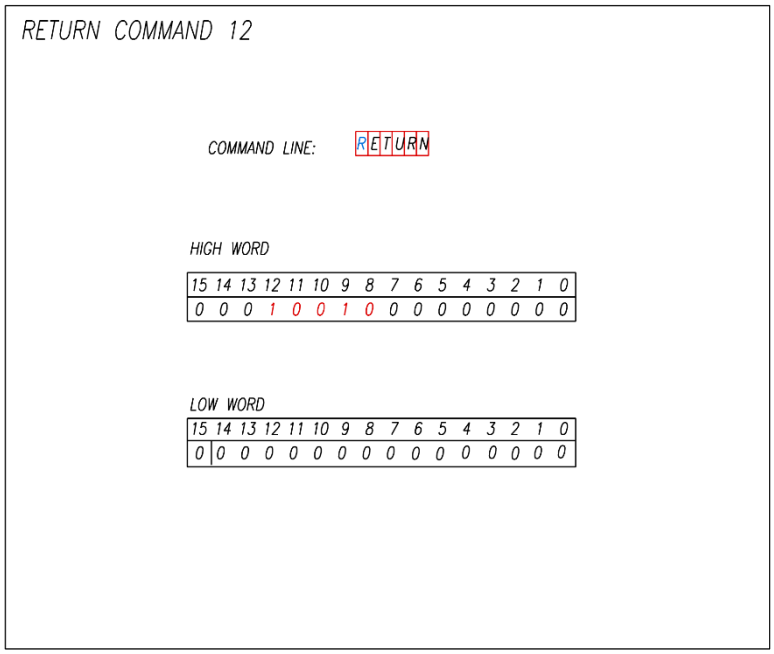
EXAMPLE: **X POSITION ADJUST +/- 255 <ENTER>** **H=1000, L=00FF**
Y POSITION ADJUST +/- 32767 <ENTER> **H=5000, L=7FFF**

JOG op-code 0x11 **MOTION COMMAND**



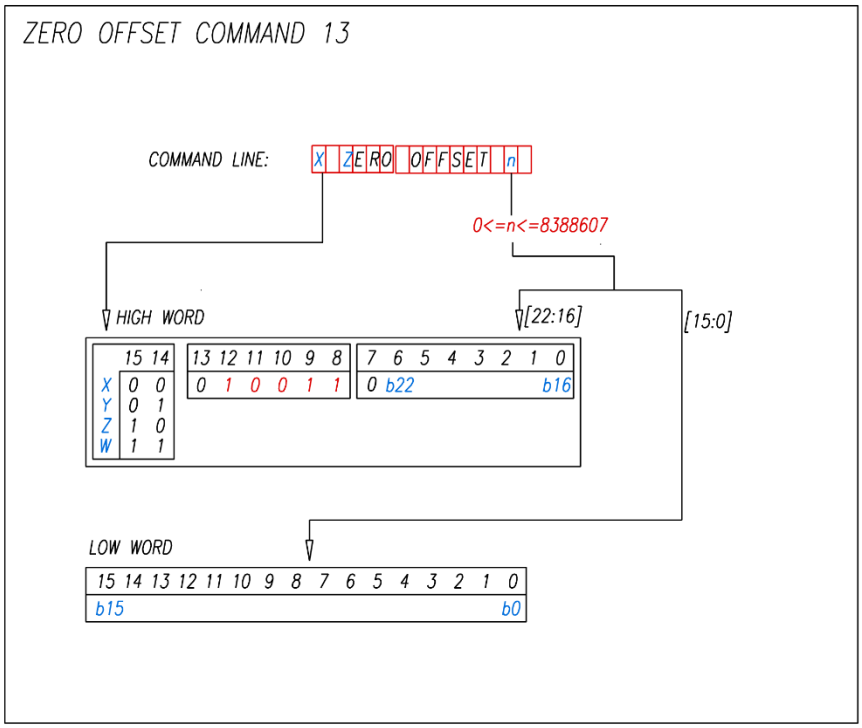
EXAMPLE: **JOG X <ENTER>** **H=1101, L=0000**
JOG X,Y <ENTER> **H=1103, L=0000**
JOG X,Y,Z,W <ENTER> **H=110F, L=0000**

RETURN op-code 0x12 **PROGRAM FLOW COMMAND**



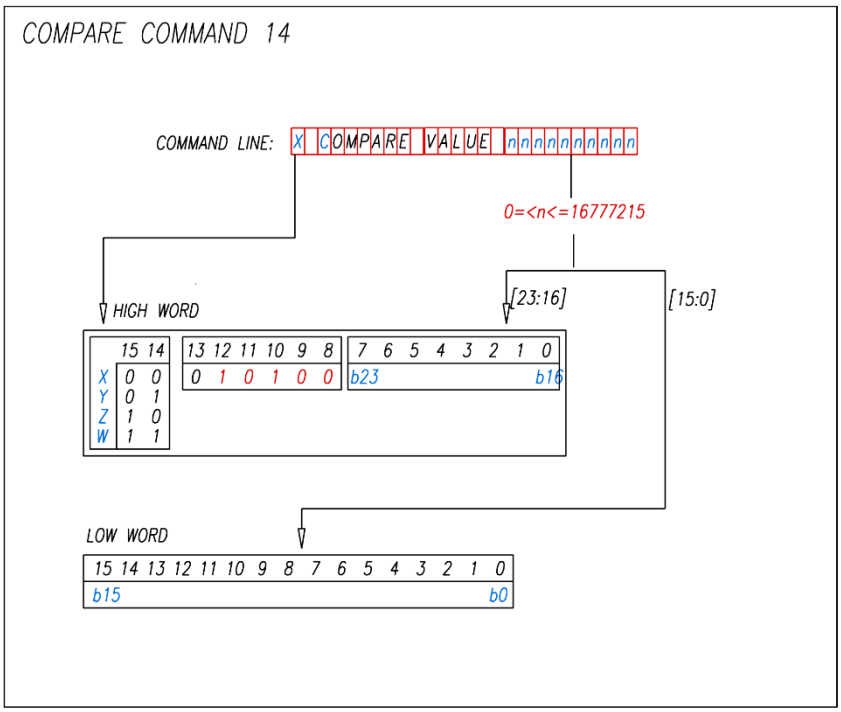
EXAMPLE: **RETURN <ENTER>** **H=1200, L=0000**

ZERO OFFSET **op-code 0x13** **CONFIGURATION COMMAND**



EXAMPLE:
X ZERO OFFSET 255 <ENTER> **H=1300, L=00FF**
Y ZERO OFFSET 65535 <ENTER> **H=5300, L=FFFF**
Z ZERO OFFSET 16777215 <ENTER> **H=93FF, L=FFFF**

COMPARE **op-code 0x14** **MISCELLANEOUS COMMAND**



EXAMPLE:

X COMPARE VALUE 255 <ENTER> **H=1400, L=3039**
Y COMPARE VALUE 65535 <ENTER> **H=1400, L=3039**
Z COMPARE VALUE 16777215 <ENTER> **H=94FF, L=FFFF**

DISCLAIMER

CERTAIN APPLICATIONS USING POWER PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY OR SEVERE DAMAGE TO PROPERTY. GECKODRIVE INC. PRODUCTS ARE NOT DESIGNED, AUTHORIZED OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR OTHER CRITICAL APPLICATIONS. INCLUSION OF GECKODRIVE INC. PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE PURCHASER'S OWN RISK

In order to minimize risks associated with the purchaser's application, adequate design and operating safeguards must be provided by the purchaser to minimize inherent or procedural hazards. GECKODRIVE INC. assumes no liability for applications assistance or the purchaser's product design. GECKODRIVE INC. does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright or other intellectual property right of GECKODRIVE INC.

MANUAL CHANGE LOG

DATE	CHANGES MADE
10/9/2014	GM215 Rev7-A Manual Published
12/10/2014	Manual format updated, release version finsalized